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An Assessment of Kitsumkalum River Summer Chinook, a North Coast Indicator Stock

R.E. McNicol

Fisheries and Oceans Canada
Stock Assessment Division
North Coast Salmon Section
300-555 West Hastings St.
Vancouver, BC
V6B 5G3

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1.0 Abstract

In 1984, the Kitsumkalum River summer chinook stock was chosen for monitoring under the chinook 'key-stream' program, which was initiated in response to objectives set out in the Canada-U.S. Pacific Salmon Treaty. The goal was to use escapement and exploitation information from this stock as an indicator of harvest and exploitation rates on B. C. north coast chinook. To that end, Peterson escapement estimates have been generated annually along with associated biological information. In addition, between 30 and 250 thousand coded-wire-tagged (CWTd) fed-fry have been released annually since 1979 (except 1982) to provide estimates of harvest and exploitation rates.

This paper represents the first comprehensive compilation and examination of the data collected to date. Most information from 1984-1996 has been obtained or derived from data contained in a series of published manuscript reports (see Data Sources). Data for 1997 and 1998 are unpublished. Two weaknesses in the data are apparent. The few CWT recoveries some years, particularly in the escapement, have probably led to exploitation rate estimates of low precision. In addition, low numbers of aging samples some years likely led to under-sampling of some age classes in the escapement. Changes to program operations have recently been made to address these two problems.

Since 1984, escapement of this stock has varied between 5 and 24 thousand fish, with peak abundance occurring from 1987-1990. With the exception of 1987, adult production for this stock has been declining since the early 1980's which has led to several years of low escapement. Poor fry-to-age-two (FAT) survival of the 1986, and the 1988-1990 broods, contributed to lower escapement in 1991 and 1995, respectively. However, because the CWT fry releases used to estimate FAT survival spend a year in freshwater before entering the ocean (stream-type stock), it is not known whether this high mortality was due to poor freshwater or marine conditions, or a combination of the two. The cause of the poor 1997 escapement, the lowest recorded since the start of this program, is uncertain. FAT survival was only slightly below average for the major contributing broods to that run (brood years 1991 and 1992). However, circumstantial evidence suggests that wild fry may have suffered higher than normal mortality during the egg-to-fry stage, which would not be reflected in FAT survival estimates. While egg-to-fry survival is not currently monitored, high water events during and just after spawning in 1991 and 1992 may have adversely affected egg survival those years. Low flow conditions may have also adversely affected early survival of the 1985 brood.

Stock-recruit analyses indicate that this stock has been exploited at an unsustainable level most years since the start of the monitoring program. While fishing-related mortality has occasionally reached above 60%, mean mortality has been about 45% (excluding natural mortality). However, as a result of recent harvest restrictions on Canadian fisheries, exploitation rates for the most recent completed brood (1992) declined to 39%, and was only 20% for the 1998 calendar year (1992-1995 broods). That year, Canadian fisheries accounted for only 21% of Kitsumkalum chinook harvested. Nevertheless, it is recommended that exploitation of this stock not be increased, at least until brood survival improves.

Assuming exploitation rates remain low in 1999, then based on estimated FAT survival rates for the incomplete 1993 and 1994 broods, and the relatively strong return of five year olds in the 1998 escapement, total 1999 escapement of Kitsumkalum chinook should exceed the 1998 level of 11,065 fish.

1.1 Résumé

En 1984, le stock de saumons quinnats d'été de la rivière Kitsumkalum a été choisi pour faire l'objet d'un contrôle dans le cadre du programme des cours d'eau « clés » du saumon quinnat. Ce programme a été élaboré dans le but d'atteindre les objectifs énoncés dans le traité Canada-États-Unis sur le saumon du Pacifique. Il s'agissait d'utiliser les renseignements sur les échappées et l'exploitation de ce stock à titre d'indicateurs de la récolte et du taux d'exploitation du saumon quinnat de la côte Nord de la C.-B. À cette fin, des estimations des échappées de Peterson ont été produites à chaque année en plus des renseignements biologiques connexes. En outre, de 30 à 250 000 alevins nourris marqués par fil codé (CWT) ont été remis à l'eau à chaque année depuis 1979 (sauf en 1982) afin d'obtenir des estimations de la récolte et des taux d'exploitation.

Pour la première fois, on trouve dans ce document la compilation et l'examen détaillés des données recueillies jusqu'à maintenant. La plupart des renseignements sur la période 1984-1996 ont été obtenus ou dérivés de données présentées dans une série de rapports manuscrits publiés (voir les sources de données). Les données pour 1997 et 1998 sont inédites. Les données souffrent de deux faiblesses. Le faible taux de récupération de fils marqués au cours de certaines années, notamment en ce qui a trait aux échappées, a sans doute donné lieu à des estimations de taux d'exploitation dont la précision est faible. En outre, le nombre restreint d'échantillons ayant servi à la détermination de l'âge au cours de certaines années a sans doute donné lieu à un sous-échantillonnage de certaines classes d'âges au sein des échappées. Des modifications ont récemment été apportées au fonctionnement du programme afin d'éliminer ces deux problèmes.

Depuis 1984, les échappées de ce stock ont varié entre cinq et vingt-quatre mille poissons, le pic d'abondance ayant été noté de 1987 à 1990. À l'exception de 1987, la production d'adultes de ce stock diminue depuis le début des années 1980 et cela a donné lieu à plusieurs années de faibles échappées. Le faible taux de survie de alevin à poisson d'âge 2 de 1986 et les faibles générations de 1988 à 1990 ont donné lieu à, respectivement, de faibles échappées en 1991 et 1995. Mais comme les alevins marqués par fil codé utilisés pour estimer le taux de survie jusqu'à l'âge 2 passent un an en eau douce avant d'atteindre l'océan (stock de type cours d'eau), on ne sait pas si la mortalité élevée s'explique par de mauvaises conditions en eau douce ou en mer ou est une combinaison des deux. La cause de la faible échappée de 1997, la plus faible notée depuis le début du programme, demeure incertaine. La survie des alevins jusqu'à l'âge 2 n'était que seulement légèrement inférieure à la moyenne dans le cas des principales générations de cette remontée (années de ponte de 1991 et 1992). Par ailleurs, des indices indirects portent à croire que les alevins sauvages peuvent avoir subi un taux de mortalité plus élevé que la normale pendant le stade de développement de l'œuf à l'alevin, ce qui ne serait pas reflété dans les estimations de survie de alevin à âge 2. Le taux de survie de œuf à alevin n'est pas actuellement contrôlé, mais des épisodes de hautes eaux pendant et tout juste après le frai en 1991 et 1992 pourraient avoir nui à la survie des œufs pendant ces années. Des débits faibles pourraient aussi avoir été néfastes à la survie des jeunes produits en 1985.

Les analyses stock-recrutement montrent que ce stock a été exploité à un niveau non soutenu au cours de la plupart des années depuis le début du programme de contrôle. La mortalité connexe à la pêche a parfois dépassé 60 %, mais la mortalité moyenne a été d'environ 45 % (à l'exclusion de la mortalité naturelle). Mais suite aux limites de récolte récemment imposées aux pêches canadiennes, le taux d'exploitation de la génération la plus récente (1992) a diminué à

39 % et n'était que de 20 % pour l'année de calendrier 1998 (pontes de 1992 à 1995). Au cours de cette année, les pêches canadiennes ne se sont accaparées que 21 % des saumons quinnats de la Kitsumkalum qui ont été récoltés. Il est cependant recommandé que l'exploitation de ce stock ne soit pas accrue, du moins tant qu'il n'y aura pas amélioration du taux de survie des jeunes.

Si l'on suppose le maintien de faibles taux d'exploitation en 1999, et que l'on utilise la survie estimée d'alevin à âge 2 pour les générations incomplètes de 1993 et 1994, et une remontée relativement importante des individus de cinq ans au sein de l'échappée de 1998, l'échappée totale de 1999 de saumons quinnats de la Kitsumkalum devrait être supérieure au niveau de 1998 soit 11 065 poissons.

2.0 Background

The Kitsumkalum River drains an area of approximately 2180 km^2, flowing 100 km in a southerly direction to its confluence with the Skeena River at Terrace, BC (Fig. 1). Considerable glacial till in runoff from tributary streams during spring to late fall creates high turbidity. All six Pacific salmon species spawn in this system, which also supports resident Dolly Varden and cutthroat trout. There are two distinct chinook runs in this system. A small early-run group spawns above Kitsumkalum Lake in Cedar River and Clear Creek in late July through late August (Morgan 1985; Alexander and English 1996), with an unknown number also spawning in the Upper Kitsumkalum River. A much larger summer stock spawns in the mainstem of the Kitsumkalum from the Skeena confluence to just below Kitsumkalum Lake (a distance of ~ 22 km) from late August through September. This chinook stock is one of the three most abundant in the Skeena system, along with the Bear and Morice River runs. These fish are highly prized by anglers due to their exceptionally large size, with fish commonly exceeding 30 kg.

During the 1940s and 1950s, the Kitsumkalum River was heavily impacted by commercial logging activity. Between 1954 and 1956, a series of dikes, and log and rock cribbing were constructed in order to channelize the river and thus reduce log jamming. This construction resulted in blocked off side channels, and the removal of gravel bars, with the subsequent loss of spawning and rearing habitat. In addition, log drives and frequent log jams caused significant gravel scouring. The last log drive occurred in 1957. While gravel recruitment has restored some of the lost spawning habitat, most of the original dikes remain in place today.

In response to objectives set by the Canada-U.S. Pacific Salmon Treaty in 1984, the Kitsumkalum summer chinook population (henceforth referred to as Kitsumkalum chinook) was chosen as a 'key-stream' stock for the purpose of tracking escapement and exploitation rate trends in a north coast chinook population. No detailed assessment of this stock has been conducted to date, although some data were presented in two earlier assessment documents on Skeena River chinook (Riddell and Snyder 1989; Peacock et al. 1996). The purpose of this paper is to assess the stock status of Kitsumkalum chinook based on biological and CWT information accumulated over the past 14 years, provide a summary of available biological and catch information on this stock, and to assess how representative this run is as an escapement and exploitation indicator for north coast chinook populations.

3.0 Data Sources

The primary source of information for this assessment was a series of manuscript reports which provide annual mark-recapture estimates for the years 1984-1996 with associated biological information (Andrew and Webb 1988; Carlsfeld et al. 1990; Nass and Bocking 1992; Nelson 1993a; 1993b; 1994; 1995a; 1995b; Blakley and Nelson 1998). Information for 1997 and 1998 has not yet been published. Earlier escapement information for Kitsumkalum chinook, as well as escapement data for other Skeena chinook stocks were obtained from a database maintained on the North Coast network drive (\\PACNCDFP1\PUBLIC). Skeena chinook test fishery and Babine fence jack chinook counts were provided by L. Jantz (DFO, Prince Rupert). Annual CWT recoveries from the various fisheries were obtained from the Mark Recovery Program database maintained at the Pacific Biological Station in Nanaimo. Escapement CWTs, and most biological data, were obtained directly from the above cited references, or calculated from data contained in them. There were several additional sources of biological information (Morgan 1985; Roni 1992; Peacock et al. 1996; Deep Creek Hatchery, unpublished data).

4.0 Enhancement History

Enhancement efforts on this system started during a biophysical reconnaissance study from 1975-1980 (Morgan 1985). Variable numbers of wild fry and smolts from brood years 1975, 1976, 1977 and 1979 were marked with CWTs and released (Appendix 1). In 1980 and 1981, chinook eggs were collected from wild spawners and incubated in a pilot hatchery located on Dry Creek (near the confluence of the Kitsumkalum River and the north end of Kitsumkalum Lake) to provide CWT fry for release the following spring. No eggs were collected in 1982, but since 1983, eggs have been collected from wild adults annually for incubation in the Deep Creek hatchery, located on Deep Creek (Fig. 1), to provide fed-fry for CWT tagging and spring release. Annual brood releases have ranged from 31,000 to 250,000. The current target is 200,000 CWT fed-fry for mid-May release. In 1997, 25,000 1996 brood were held over for release as yearlings in the spring of 1998. This additional release was done to provide an estimate of yearling survival and increase CWT recoveries. Only releases from 1979 on were used for exploitation rate estimates.

Initially, the release of CWT fry was timed to match the observed timing of outmigrating wild fry (see below). However, fry releases from the 1992-1996 broods were significantly later, extending some years to mid-June. Starting with the 1997 brood, feeding rates were increased, which produced 2.4 g fish by mid-May.

5.0 Biological Characteristics

5.1 Life History

There has been relatively little study of the biology of Kitsumkalum chinook. From 1975-1980, a biophysical reconnaissance was conducted to provide basic life history information on this stock (Morgan 1985). This work involved, among other things, trapping and enumerating juvenile outmigrants of all salmon species, as well as spawner enumeration, collection of biological samples, and physical and chemical measurements of river water.

Results of this study indicate that Kitsumkalum chinook juveniles migrate out of the Kitsumkalum into the Skeena River, primarily as 30-60 day fry, from mid-April to mid-May. A much smaller number of 1+ smolts outmigrate in mid-April. Adult spawners, consisting of both red and white fleshed fish, return primarily as 5 and 6 year olds in late July, to spawn from late August through to the end of September.

Based on Peterson mark-recapture estimates, the sex ratio of escapement is approximately 1:1. While a preponderance of females are encountered during carcass recovery, this is likely due to a tendency for males, after spawning, to drift out of the river before dying. Conversely, during tagging operations, tangle-netted catch is usually dominated by males at a mean ratio of 4:3. However, this sex ratio may also be biased. Scales indicate that over 95 % of Kitsumkalum chinook spend one year in freshwater before moving into the marine environment (see below). However based on Morgan's (1985) fry trapping observations, most fry of this 'stream-type' stock appear to overwinter outside the Kitsumkalum system, presumably in the lower Skeena River. However, this has not been confirmed.

5.2 Age Structure

Scale samples show that over 95% of returning adults have one 'freshwater' annulus (Appendix 2). Prior to 1980, scale age readings indicated a predominance of sub-1 fish, i.e. fish that, as fry, spent less than one year in freshwater before migrating into the ocean. However, what appears as an abrupt change in life history is likely an artifact due to changes in chinook scale age interpretation (Tutty and Yole 1978) starting in 1980.

Since the start of the 'key-stream' program in 1984, the number of aging samples collected has varied. While for most years, enough samples (scales) were taken to provide a reasonable estimate of age composition of the return, fewer than 300 were aged in 1987, 1991, and 1994-1997. Recent changes to the sampling protocol (fins to be collected when scales are difficult to extract) should assure that a minimum of 500 samples will be collected in the future. In 1997 and 1998, considerable numbers of hatchery fish heads were collected for CWT extraction. At the same time, scale samples were taken to allow an assessment of the accuracy of total age determination from Kitsumkalum chinook scales. In 1997, 17.2 % of age 5 fish were incorrectly aged as age 6, while 6.7 % of age 6 fish were incorrectly aged as age 5. In 1998, the percentages were 13.3 and 12.0 %, respectively. Consequently, total age composition of aging samples were adjusted accordingly for these years.

Approximately 90% of returning adults have been 5 and 6 year olds, with age 6 fish predominating in all years except 1985 (Table 1; Fig. 2). Virtually no age 3 females are encountered in the escapement, and while jacks (< 50 cm POH) are estimated to comprise < 3% of the escapement, this is likely an underestimate. Rapid flushing of jack carcasses from this system leaves few available for carcass recovery, making mark-recapture estimates impossible most years. Four year olds typically comprise < 5 % of the escapement, while fewer than 3 % of returns are 7 year olds. Over the 1984-1998 period, average age of female escapement was 5.71 years, while that of males was 5.46 years. While six year olds have predominated consistently since 1986, the proportion of 5 year olds has been rising over the past three years.

5.3 Size at Age

Kitsumkalum chinook are among the largest salmon on the west coast. A recent survey of 108 North American chinook stocks by Roni (1992) determined that Kitsumkalum adult males and females spawners attained the largest average size of any other stock, including those in the Wannock (B.C.) and Kenai (Alaska) Rivers. Weighted mean POH length of spawning males since 1984 has ranged between 765-895 mm, while those of females have ranged between 825-955 mm (Table 2). The smallest and largest fish captured in any season tend to be males (Fig. 3), though there is no consistent difference in mean lengths between sexes (Table 2). There does not appear to have been any change in size at age, or mean overall size of returning males or females since 1984 (Fig. 4). One exception to this is the virtual disappearance of males <50 cm POH between 1990 and 1997. However, both tagging observations and carcass recoveries indicate that significant numbers of such fish returned in the 1998 escapement.

5.4 Fecundity

Only data from the1994 and 1998 brood collections were available to determine a length-fecundity relationship. Figure 5 illustrates the weak but significant linear relationship between fish size and egg number. The mean POH length and egg number for this group of fish is 856 mm and 7520 eggs, respectively. However, these egg numbers may underestimate actual fecundity, since the 1994 records did not indicate whether fish were all unspent when captured. Morgan (1985) observed 31.4% of female carcasses examined in 1978 had retained eggs, though mean egg retention averaged only 2 % of mean fecundity. Recent observations indicate that egg retention in this stock remains very low. Only 2 out of 635 females examined in 1998 had retained significant numbers of eggs; one retained ~25 % of her eggs, while the other was a prespawn mortality. In general, since 1990, female carcasses containing more than a small number of eggs are rarely encountered (C. Culp, personal communication).

5.5 Hatchery Contribution to Escapement

Hatchery releases generally comprise a small portion of escapement in the Kitsumkalum. Between 1984 and 1996, hatchery fish typically comprised less than 3 % of total escapement (Fig. 6). However, in 1997, an unprecedented 8 % of spawners were hatchery fish. Numbers then declined in 1998 to approximately 4 %. Strays from other hatcheries are rarely recovered in this river. Note that the low hatchery escapements in 1987 and 1988 are due in part to no releases for the 1982 brood.

6.0 Escapement

6.1 Methodology

Quantitative escapement estimates for Kitsumkalum chinook have been recorded annually since 1961, with the exception of 1963. Prior to 1984, chinook escapement estimates were derived from visual inspections by a fishery officer. However, the highly turbid condition of the river during spawning makes it difficult to see fish, except when breaking the water surface. Between 1978 and 1983, numbers were estimated from a combination of spot counts of spawners in shallow spawning areas, and redd counts during the winter, when water clarity improves considerably (J. Hipp, personal communication). However, it is not known exactly how estimates were derived prior to 1978. Since 1984, a mark-recapture program in the river

below Treston Lake has provided adjusted Peterson escapement estimates; the results for 1984-1996 are reported in a series of manuscript reports (Andrew and Webb 1988; Carlsfeld et al. 1990; Nass and Bocking 1992; Nelson 1993a; 1993b; 1994; 1995a; 1995b; Blakley and Nelson 1998). Unfortunately, visual estimates did not continue after 1983, making it impossible to calibrate pre-1984 visual escapement estimates to mark-recapture estimates from 1984 on.

The mark-recapture program involved tangle-netting adults while boat-drifting over holding and spawning areas, and applying an external tag (Peterson discs in 1984, spaghetti tags in 1985-1986, and Kurl-Lock tags thereafter). This operation usually began in the third week of August and continued on into the third week of September. Carcass recovery usually began in the first week of September and continued into the first week of October. Retrieved carcasses provided counts of tagged and untagged fish, aging samples (scales and fins), POH lengths, etc. The heads of adipose-clipped fish were collected for CWT retrieval.

Below Treston Lake, the river is naturally divided into an upper and lower section by a 3 km stretch of canyon rapids approximately 10 km upstream of the Skeena confluence (Fig. 1). While these rapids do not act as a barrier to fish migration, it was felt that potential differences in tagging rates and tag recovery above and below the canyon might bias a pooled estimate. Consequently, population estimates were stratified by section (with the exception of the 1984 estimate); 'lower river' refers to the section of river between the Skeena confluence and canyon rapids, while 'upper river' refers to the section between canyon rapids and Treston Lake. This terminology should not be confused with Upper Kitsumkalum and Lower Kitsumkalum; the former refers to the section of river above Kitsumkalum Lake, and the latter to the river below the lake.

Adjusted Peterson estimates and their confidence intervals (Ricker 1975; p. 78-80) were calculated from data stratified by sex and river section, except in 1984; due to poor tag recoveries in the upper river that year, data were stratified by sex only (Andrew and Webb 1988). A review of the calculations revealed that for some years, estimates were incorrectly derived. For the years 1986-1990 (Andrew and Webb 1988; Carolsfeld et al. 1990; Nass and Bocking 1992), jack estimates were inappropriately calculated from fewer than three mark recoveries (and in several instances, from zero recoveries!) and added to the total estimate. Consequently, population estimates for those years were revised downward. While in most of these cases corrected estimates did not decline markedly, for 1990 the corrected estimate was 13.7%, or 2890 fish, lower than that reported (Nass and Bocking 1992). In 1996, no estimate could be calculated for upper river males due to zero tag recoveries.

6.2 Escapement Trends 1961-1998

Escapement to the Kitsumkalum increased through the 1960s, 70s and early 80s (Fig. 7a). While this increase may have been the result of improved logging practices, changes in enumeration techniques through those years cannot be ruled out as a factor. In 1977, a single mark-recapture estimate was compared to an independent visual estimate (Morgan 1985). The visual estimate was only 300 fish lower than the mark-recapture estimate (9,000 vs. 9,300). This is higher that the number reported in the North Coast and SEDS escapement databases (7500).

Since the start of the key stream program in 1984, escapement has ranged between approximately 5,000 and 24,000 fish (Table 3; Fig. 7a). Escapement peaked in 1987 and 1988 at record numbers of 24,000 and 22,000 fish, respectively. Numbers then declined until

reaching pre-1987 levels by 1991. By 1997, escapement had declined to its lowest level (5,342) since the start of the mark-recapture program. However, escapement rebounded in 1998 to over 11,000 fish. Under the chinook rebuilding program associated with the Pacific Salmon Treaty, interim escapement goals were set based on the average escapement for 1979-1982 (see discussion of rational in CTC 1998). Although this goal was not applied to individual Skeena stocks, based on this formula, the goal for the Kitsumkalum would have been 12,000 spawners. These escapement goals were later changed to be double the 1984 escapement (the first year of mark-recapture estimates). This change was implemented due to concern that pre-1984 escapements, for many systems, were derived from inaccurate visual counts (CTC 1998). For the Kitsumkalum, this change increased the escapement goal to 23,650 fish. Escapement to the Kitsumkalum exceeded the interim goal from 1987 – 1990 and 1992-1994. Only the highest recorded escapement (1986) even approached the revised goal. However, because these goals were not based on any biological criteria *per se*, they probably have little meaning for this stock.

Jack escapement estimates could only be calculated for the years 1986, 1990 and 1998 due to poor recoveries of tagged fish. Therefore, the number of jacks tagged annually was used as a crude surrogate measure of jack abundance. Unfortunately, since effort was not recorded most years, there was no way to standardize counts between years (i.e. as catch-per-unit-effort). Nevertheless, these numbers indicate that jack abundance had declined through the 1990s, reaching a low in 1995 (Fig. 8). However, numbers increased significantly in 1997, and dramatically in 1998. There are several indications that this measure may accurately reflect relative changes in jack abundance. A similar decline in jack numbers was observed at the Babine fence through the same period. Similarly, the Skeena jack test fishery index also declined sharply through the early to mid-1990s. Between 1984 and 1997, tagging counts of Kitsumkalum jacks have been moderately correlated with both the Skeena jack chinook abundance index, ($r=0.67$, $p=0.009$); this relationship diminishes when the unusual 1998 data are included.

7.0 Cohort Analysis and CWT Escapement

7.1 Methodology

A cohort analysis was conducted using estimated CWT recoveries (both catch and escapement) to determine survival and exploitation rates, as well as exploitation patterns for this stock. The cohort model used is documented in Appendix 2 of Starr and Argue (1991) and as modified by the Chinook Technical Committee (CTC) of the Pacific Salmon Commission (PSC, TCCHINOOK (98)-1). Only the brood year method was used in determining incidental mortality. The cohort model was modified by the CTC to account for the chinook non-retention fisheries implemented in Canada during 1996. Modifications are documented by the CTC in Appendix G of TCCHINOOK (98)-1. For this stock, complete brood year CWT escapement is available only for brood years 1983-1992. Because escapement CWT recoveries were not reported prior to 1985, CWT escapements are incomplete for broods 1979-1981 (no CWT fish were released in 1982). However considering that over 90 % of returns to this system are age 5 or 6, it is likely that only the 1979 brood CWT escapement is significantly underestimated, causing the estimated exploitation rate for this brood to be biased upwards.

For each brood year, the cohort analysis provides the following information:

- annual distribution of catch and total fishing mortalities;

- survival of CWT groups to age 2 recruitment;
- total exploitation rates by fishery and age.

For most years, CWT recoveries for Kitsumkalum chinook have been relatively low. Total observed recoveries (catch + escapement), by brood year, have been as low as 21 and only as high as 200 (Table 4). Tag recoveries in the escapement have in some years been especially poor. In 1995 and 1996, only 4 and 11 CWTs, respectively, were recovered during carcass recovery (Nelson 1995b; Blakley and Nelson 1998). Due to such recent low recoveries among carcasses, a limited number of adipose-clipped fish were sacrificed during the tagging operations in 1997 (60) and 1998 (28). While removing such fish during tagging would bias downward the number of CWT fish encountered during carcass recovery, it was felt that the derived estimated CWT escapement, biased as it was but based on more tag recoveries, would be more accurate than one derived from the small number of tags recovered during carcass recovery alone. This measure significantly improved CWT recoveries in 1997 and 1998.

While all CWT escapements reported in the previously cited manuscript reports were calculated using the same general approach, how recoveries were stratified and expanded sometimes differed. In addition, where escapement estimates had to be recalculated, so too did estimated CWT escapements. For proper year-to-year comparisons, it was necessary to calculate CWT escapements using the same stratification approach for all years, where possible.

The stratification approach used was that described by Carlsfeld et al. (1990). Briefly, counts of adipose-clipped fish were stratified by condition (live or dead), sex, and river section (upper and lower) whenever possible. Total number of adipose-clipped fish in the escapement was estimated by calculating a weighted average of the estimated number of adipose-clipped fish at the time of tagging, and at the time of carcass recovery. To estimate adipose-clipped escapement based on carcass recovery samples:

$$EAD_{i,r,\,dead} = (OAD_{i,r,\,dead} * P_{i,r})/C_{i,r,\,dead}$$

where $EAD_{i,r,\,dead}$ is the estimated number of adipose-clipped fish in the escapement at the time of carcass recovery, $OAD_{i,r,\,dead}$ is the number of adipose-clipped fish observed during carcass recovery, $P_{i,r}$ is the Peterson estimate adjusted for strays (fish tagged in the lower river, but retrieved in the upper river, and vice versa), and $C_{i,r,\,dead}$ the total number of fish examined during carcass recovery, by sex i and river section r. To estimate adipose-clipped escapement based on live tagging samples:

$$EAD_{i,r,live} = (OAD_{i,r,live} * P'_{i,r})/C_{i,r,live}$$

where $EAD_{i,r,live}$ is the estimated number of adipose-clipped fish in the escapement at the time of tagging, $OAD_{i,r,live}$ is the number of adipose-clipped fish observed during tagging, $C_{i,r,live}$ is the total number of fish examined during tagging, and $P'_{i,r}$ is the estimated population present during tagging by sex i and river section r, such that:

$$P'_{i,r} = P_{i,r} + (ES_{i,r}/PR_{i,r}) - (ES_{i,r'}/PR_{i,r'})$$

where $ES_{i,r}$ and $ES_{i,r'}$ are the expanded number of tagged strays, and $PR_{i,r}$ and $PR_{i,r'}$ are the punch rates, for each river section (r and r') where:

$$ES_{i,r} = S_{i,r} * M_{i,r}/R_{i,r}$$

with $S_{i,r}$ being the number of punched strays for river section r, and $M_{i,r}$ the total number of tags applied in this section, and $R_{i,r}$ the number of tags recovered, by sex i for the same section, and

$$ES_{i,r'} = S_{i,r'} * M_{i,r'}/R_{i,r'}$$

where $ES_{i,r'}$, $S_{i,r'}$, $M_{i,r'}$ and $R_{i,r'}$ are the same as above, but for the other river section, r'.

The escapement of each tag code was then estimated by allocation to tag codes based on their relative frequency in the sample of decoded tags:

$$EAD_{i,r,tc} = (EAD_{i,r,wt} * OAD_{i,r,tc})/NDT_{i,r}$$

where $EAD_{i,r,tc}$ is the estimated number of CWT escapements by tag code (tc), $EAD_{i,r,wt}$ is the weighted mean of $EAD_{i,r,live}$ and $EAD_{i,r,dead}$, $OAD_{i,r,tc}$ is the observed number of tags by tag code, and $NDT_{i,r}$ the total number of decoded tags.

7.2 Results

7.2.1 Cwt Survival

Because most returning CWTd adults show a 'freshwater' annulus, it's assumed that after release as fry, they, like their wild counterparts, remain in a freshwater environment through the following winter before migrating to sea. Consequently for this stock, the survival rates to age 2 calculated by the cohort analysis, reflect mortality from the fry-to-smolt stage, as well as into the first year of ocean life (early marine). Since all CWT releases up to 1996 have been as fry, there is no way to estimate separate rates for each phase at this time.

Fry-to-age 2 (FAT) survival rates have varied considerably for this stock, ranging from 0.16-3.16 % (Fig. 9). Survival was relatively high from 1980–1985. However, survival then dipped to 0.23 % in 1986, only to rise to near 2 % for the 1987 brood. Survival then plummeted again to under 0.5 % from 1988 – 1990. Survival returned to more typical levels for the last two complete brood years (1991, 1992). Estimates for the incomplete 1993 and 1994 broods are based on recoveries to date and average maturation rates from completed broods. While survival of the 1993 brood dipped to 0.73%, survival of the 1994 brood was much higher at 3.16%.

7.2.2 Brood Harvest and Exploitation

Patterns of CWT recoveries in the various fisheries provide some indication of run timing (Fig. 10). However because effort is not taken into account, these data may be biased. Kitsumkalum chinook are caught in Alaskan waters primarily in the first half of July, and are vulnerable to the northern B.C. troll and net fishery throughout most of that month (Fig. 10). While some are caught in the tidal sport fishery in June, numbers peak in July. The freshwater sport fishery on Kitsumkalum chinook does not begin until early July, and continues into the first two weeks of August.

Prior to the Pacific Salmon Treaty, U.S. commercial fishers were harvesting the majority of the Kitsumkalum chinook catch, primarily in the July outside troll fishery (Table 5). However, from 1986 to 1996, Canada was responsible for between 54 and 70% of total catch mortality

(including incidental mortalities). During this period, the Alaskan July outside troll fishery continued to account for the large majority of U.S. chinook harvest, while in Canada most Kitsumkalum chinook were caught in the northern net, and to a lesser extent, the northern troll fishery. However in 1997, U.S. catch accounted for 52% of total catch mortality, as a result of reduced harvest by Canadian commercial fisheries (Fig. 11). The Canadian troll fishery did not catch any Kitsumkalum chinook that year. In 1998, following severe Canadian harvest restrictions, total fishing mortality dropped to 20.4%. Only 21% of total catch mortality occurred in Canadian waters, primarily in the sport fisheries (Table 5).

Exploitation rates for the 1979 and 1980 broods were above 60 %, but then declined sharply to under 40 % for the 1981 brood (Fig. 12). However, exploitation rates gradually increased from 37 to 65 % by the 1989 brood. Thereafter, exploitation rates declined for the 1990 (41%), 1991 (49%), and 1992 (39%) broods.

7.2.3 Brood Production

Total brood adult production was calculated as follows. For each age class, brood escapement at age was divided by (1-terminal harvest rate for that age class) to calculate terminal return. For Kitsumkalum chinook, terminal harvest consisted of all age 5 and 6 fish captured in net fisheries, and all fish captured in the freshwater sport fishery. Total terminal return was then divided by the maturity rate for that age class, to determine the population size after the pre-terminal fishery. Dividing this number by (1-ocean exploitation rate) determined the pre-fishery ocean population size. The difference between the pre-fishery and pre-terminal ocean population constituted total ocean fishing mortality. This value was then multiplied by the adult equivalent factor to convert the mortalities to adult equivalents. Total adult production for that age class equaled the sum of fishing mortality and terminal return. Summing adult production at all ages gave the total adult production for that brood (Appendix 3).

With the exception of the 1987 brood, adult production has been in general decline since 1981 (Fig. 13a). The first large decline occurred in the 1985 and 1986 broods. Following a return to pre-1985 production levels in 1987, recruitment sharply declined in 1988, and continued to remain low through 1992, the most recent complete brood.

7.2.4 Stock-Recruit Relationship

The relationship between spawner abundance and subsequent adult recruits was examined using SRSHOW, a software program developed by C.J. Walters, University of British Columbia, B.C. Optimal exploitation rate (U_{opt}) and optimal escapement (S_{opt}) were estimated for Ricker stock-recruit curves with log-normal error ($R=\Sigma\alpha e^{-\beta S+\varepsilon}$, where R=total adult recruits of all ages, S=number of spawners, α and β are parameters, and ε is a standard normal random variate). Using the maximum integrated likelihood criterion, the best estimate of U_{opt} and S_{opt} is 43.6% and 8876 spawners, respectively (Fig. 14a). The regression of adult ln(recruits/spawner) versus spawner abundance indicates that the maximum potential adult recruitment per spawner is 3.0 fish (Fig. 13b).

An additional Bayesian estimate of optimal exploitation rate (Walters and Ludwig 1994) was derived by taking the expected value of all values of U_{opt} and S_{opt} within the specified ranges weighted by their respective likelihoods (Fig. 14c). The Bayesian estimate for U_{opt} is much lower, at 35.7% (Fig. 14b) because it takes into account our uncertainty about the true parameter values assuming that the data are reliable. However, there are additional sources of

uncertainty that must be considered. Statistical bias is expected because of large measurement error in the escapement estimates (Ludwig and Walters 1981). Furthermore, the plot of residuals from the best-fitting Ricker curve indicates significant autocorrelation in the recruitment data (r=0.51; Fig 14d) reflecting the tendency for recruitment in successive generations to be directly related to brood escapement size. This level of autocorrelation will cause a statistical time series bias in estimates of U_{opt} and S_{opt} derived from short time series (Walters 1985). Measurement error bias and time series bias both cause U_{opt} to be overestimated and S_{opt} to be underestimated.

8.0 Kitsumkalum Chinook as a North Coast Indicator Stock

The Skeena system supports the majority of chinook stocks along the north coast, comprised of both large and small populations with early to late migration timings and spawning periods. These stocks span a distance extending from the coast to over 300 km inland. The Kitsumkalum 'key-stream' program was implemented primarily to provide estimates of exploitation rates on north coast chinook, under the assumption that exploitation of this stock was similar to that sustained by other Skeena and north coast chinook stocks. This stock was a logical choice for monitoring since it is of such a size that large numbers of CWT fry could be released without much concern of 'swamping' natural fry production, access to the river for tagging and netting fish is convenient, and there was already a functioning hatchery in place. Previous reviews of stock assessment information for Skeena chinook (Riddell et al. 1989; Peacock et al. 1996) discussed in some detail differences and similarities in biological characteristics, migration timing, and catch distribution among stocks. However, the question remains as to how representative this stock may be of other north coast stocks both in terms of patterns and degree of exploitation, and as an abundance indicator.

Kitsumkalum chinook is the only north coast stock for which estimated CWT recoveries are calculated from an absolute escapement estimate. Such estimates are essential for calculating true exploitation rates. CWT escapements to the Babine have been estimated starting with the 1986 brood, but are derived from partial fence counts only. Over the years, CWT releases have occurred for a number of Skeena stocks, including the Cedar, Zymoetz (Copper), Bulkley, Kispiox, Babine and Fulton Rivers. In addition, CWT fish have been released into the Yakoun (Queen Charlotte Islands) and the Kincolith (Nass system) Rivers. However, accurate estimates of CWT escapement for these stocks are not available. Consequently, direct comparisons of exploitation rates among north coast stocks is difficult. However, some inferences can be drawn regarding stock similarities from CWT catch distribution.

As previously discussed, CWT recoveries of Kitsumkalum chinook indicate that up until 1998, most fish were caught in the Alaska troll and northern B.C. net fisheries. Of the other north coast stocks examined, the summer run Skeena stocks (Zymoetz, Babine, Kispiox and Fulton) as well as the Kincolith (spring) displayed an exploitation pattern similar to that of Kitsumkalum chinook (Table 7). However, several stocks have noticeable differences in exploitation pattern. The large majority of Yakoun chinook are caught in the Alaskan and B.C. troll fisheries. The small number of CWT recoveries of Cedar chinook indicate that this stock is only lightly exploited by ocean fisheries (Alaskan and B.C.), probably due to their early run timing (Alexander and English 1996). Similarly, upper Bulkley fish are rarely caught outside of B.C. waters; most are caught in the freshwater sport fishery, with generally smaller numbers caught

in B.C. ocean fisheries. These different exploitation patterns for Kitsumkalum, Cedar and upper Bulkley stocks probably reflect their genetic distinctiveness from one another (Chris Wood, personal analysis of data from Teel et al. 1999). Simple exploitation rates (catch/(catch + escapement)) calculated for this stock for the 1986-1988 broods indicate the less than 20% of recruits are harvested annually (Peacock et al. 1996).

To assess whether there has been a relationship between fluctuations in abundacne in Kitsumkalum chinook and those in other Skeena stocks, simple correlations were calculated. Separate analyses were conducted over two time periods: 1961-1983 (the years of visual escapement records for the Kitsumkalum) and 1984-1998 (the years of mark-recapture estimates). Stocks chosen for comparison had to have no less than 15 years data between 1961 and 1983, and no less than 10 between 1984-1998. Apart from sample size limitations, there were no other *a priori* limitations to the number of stocks included for comparison. This resulted in 18 stock comparisons for the first period, and 21 for the second (Table 8). In addition, the Skeena adult chinook test fishery index (cumulative count to August 15) as well as the total escapements of the other three major Skeena stocks combined (Morice+Kispiox+Bear) were included. Stated p-values represent the significance of the calculated correlation coefficient for that pairwise comparison only, and are not corrected for multiple comparisons. They should be treated as an indication of degree of association, rather than a measure of true statistical significance.

The results of the correlation analysis, for the most part, did not indicate strong correlation between escapements to the Kitsumkalum and escapements of other stocks (Table 8). This included the Babine stock, whose relative abundance has been consistently monitored via fence counts over both periods. There appeared to be a tendency for escapement to rivers downsteam of the Kitsumkalum to be negatively correlated with Kitsumkalum escapement, particularly the Gitnadoix stock. While there appeared to be a positive correlation with total escapement to the aggregate escapement of the other large stocks between 1961 and 1983, this relationship disappeared between 1984 and 1998. However, since 1991, Kitsumkalum escapement and the Kispiox/Morice/Bear aggregate escapement have been more closely associated (Fig. 7b). There was no significant correlation with the adult test fishery index, though curiously, the correlation was negative during the first period, but positive over the later period.

Only Cedar River escapement has shown a positive correlation with Kitsumkalum escapement over both time periods (Table 8). Even though the Cedar, a tributary to the Kitsumkalum, is one of the closest stocks geographically, it supports a chinook stock quite different biologically from Kitsumkalum chinook. The ocean distribution and early migration timing of this stock ensures that it is only lightly exploitated compared to Kitsumkalum chinook. Thus, similar fluctuations in abundance are not due to similar exploitaiton rates. The above differences suggest that production for these two stocks over the period in question has been more strongly influenced by local freshwater conditions than factors in the marine environment. While it is possible that the correlation in escapements is the result of bias, whereby visual estimates made for Kitsumkalum chinook influenced those for the Cedar, such bias would not apply after 1983 when estimates were derived independently by different individuals. However, it should be noted that no such correlation with Clear Creek escapement was evident, even though this system is also a tributary to the Kitsumkalum, and also supports a spring stock.

9.0 Discussion

Abundance of Kitsumkalum chinook has shown considerable variability since the start of the mark-recapture program both in brood production and escapement. While many of the observed fluctuations can be attributed to varying FAT survival and exploitation rates, there is some circumstantial evidence that for some broods, high and low flow events during the fall and winter may have adversely affected survival during the egg-to-fry stage.

The high numbers of adult recruits from the 1981-1984 broods (Fig. 13a) appear to be the result of high FAT survival (Fig. 9). However since spawner numbers are unknown for 1981-1983, high escapement those years could have also been a contributing factor. High recruitment and relatively low exploitation on these fish resulted in record escapements between 1987 and 1990.

Escapement in 1985 and 1986 was relatively low, and though number of recruits per spawner were high for those broods, total brood production dropped to half the previous highs. FAT survival from CWT recoveries was also moderately low in 1985 but very low in 1986. A decline in brood production in 1985 was also observed for Skeena River chinook in general. The 1988-1991 Skeena test fishery index indicated very low returns of 3, 4, 5 and 6 year olds, respectively, from this brood (Peacock et al. 1996). Similarly, brood production for a number of Fraser River salmon stocks, including Harrison River chinook, was also poor in 1985 (B. Riddell, personal communication). One factor which may have adversely influenced early freshwater survival that year is low fall flow conditions. Terrace air temperatures during November of 1985 were some of the coldest on record (Environment Canada). Though no flow records exist for the Kitsumkalum beyond 1952, up to date records are available for the Zymagotiz River, a tributary to the Skeena located approximately 5 km downstream of the Kitsumkalum (also glacier-fed, but without a headwater lake). The low November temperatures in this system that year led to November flow rates which were the lowest recorded since 1971 (Fig. 15a). Assuming the Kitsumkalum system was similarly affected, then a combination of low temperatures and low water levels could have led to de-watering of redds and subsequent freezing or suffocation of significant numbers of eggs. However, there are no data on juvenile abundance the following spring to confirm this. Flow and temperature conditions in 1986, based on Zymagotitz River data, were not abnormal suggesting that early freshwater conditions were not a factor in the low survival observed for that year class. Consequently, extremely poor FAT survival may have been the primary cause of poor production that year. Together, these consecutive poor broods produced a low 1991 escapement. The sharp increase in brood production in 1987 was probably due at least in part to relatively high FAT survival.

Through the 1988-1990 broods, FAT survival was much lower than normal, possibly due to poor marine conditions in the early 1990s (these fish would have gone to sea in 1990-1992). Poor recruitment and a higher than normal exploitation of the 1989 brood, resulted in an escapement of 7,220 fish in 1995, the second lowest since 1984.

The 1997 escapement was unusual in two respects: the point estimate (5,342) was the lowest recorded since the start of the mark-recapture program, and hatchery returns comprised more than double their normal percentage of total escapement (8 vs. <3%). Like the wild escapement, hatchery returns consisted of about equal numbers of 5 and 6 year olds. Since escapement is comprised primarily of 5 and 6 year olds, low escapement in 1997 indicates poor production from the 1991 and 1992 broods. Neither the 1991 or 1992 escapements were very low, suggesting that low egg deposition was not a factor those years. Furthermore, FAT

survival based on CWT recoveries for these brood years was only slightly below average, and exploitation was declining. Together, this information suggests that wild fry experienced higher mortality than hatchery fish. This could result if wild fry were subjected to adverse conditions during the egg-to-fry stage, which would not have been experienced by hatchery-reared fry. Thus, FAT survival may not have been an accurate reflection of total brood production those years. Though air temperatures during the winters of 1991 and 1992 were not abnormal, there is evidence that extreme high flow events occurred during the fall of those years. Record or near record high maximum daily flows were registered during September,1991, and October,1992, in the Zymagotitz River (Fig. 14b). Assuming such high flow conditions occurred in the Kitsumkalum, then several negative consequences could result. During other high water events, adults have been observed to construct redds in side channels and up river banks which become stranded once water levels recede (C. Culp, personal observation). In addition, gravel redistribution and siltation of redds could result in egg smothering (Healey 1991). Again, without measures of fry abundance the spring following these events, there is no direct evidence to draw upon. However unlike the poor 1985 brood, there is no indication in the Skeena test fishery of reduced production from either the 1991 or 1992 broods for the Skeena in general. This suggests that whatever was responsible for the low brood abundance those years may have been local in origin.

The above discussion illustrates the present gap in our knowledge of how early freshwater conditions can affect production of chinook in not just the Kitsumkalum, but north coast systems in general. Currently there are no chinook fry/smolt monitoring programs in place on any B.C. north coast system. Without measures of fry abundance to compliment CWT releases, significant early freshwater mortality events cannot be identified and their effects on brood production measured. Furthermore, age 2 survival rates for stream-type stocks calculated through CWT fry releases reflect both freshwater (fry-to-smolt) and early marine mortality; the two cannot be separated. Consequently we are currently unable to obtain separate estimates of egg-to-fry, fry-to-smolt and early marine survival for a B.C. north coast chinook population.

Since 1979, exploitation rates (including incidental mortalities) on Kitsumkalum broods have ranged from a low of 37% (1981 brood) to a high of 65% (1979 brood). While some recent brood exploitation rates have been slightly lower than the best-fit Ricker curve U_{opt} estimate of 43.7%, they are considerably higher than the Bayesian U_{opt} estimate of 35.7%; at the higher rate of exploitation there is a 32% chance of population extinction, while at the lower rate, the risk of extinction is only 20% (Fig. 14b). Stock-recruit analyses of several other northern stocks produce similar Bayesian estimates of U_{opt} (C.J Walters, personal communication). This suggests that this stock has been exploited at a non-sustainable level in recent years. However, there has been no noticeable shift in age composition to predominantly younger age classes, as would be expected if such a late maturing chinook stock were overexploited (Hankin and Healey 1986). Nevertheless, in light of the uncertainty surrounding escapement estimates, as well as the recent poor recruitments, it is recommended that exploitation of this stock not be increased beyond current levels, at least until brood survival improves.

While CWT survival rates for Kitsumkalum chinook are generally low, there is no way of knowing, without tagging wild fry, whether they closely match FAT survival rates of wild broods. Nevertheless, the lower the number of recoveries, the lower the precision of any estimates based on these recoveries. Since the 1984 brood year, between 140,000 and 250,000 fed fry have been released annually resulting in total observed recoveries varying between 21 and 200 tags. There are several approaches that could be pursued to improve CWT survival, or otherwise increase recoveries:

1) More fed-fry could be released. The Deep Creek hatchery can rear up to 25,000 fry annually. However, an additional 50,000 fry would increase recoveries by only 25%.

2) The size (and thus survival) of released fry could be increased by heating the ground water currently used for egg and fry rearing. Heating the volume of water required to rear these fish would be expensive. Furthermore, if fry are 'forced' to a size significantly larger than their wild counterparts, then they may no longer be reliable indicators of FAT survival for wild fish.

3) Fry releases could be supplemented with yearling smolt releases. A small portion of wild Kitsumkalum fish outmigrate into the Skeena as yearlings (Morgan 1985). Thus, retaining a portion of CWT fry for release as yearlings the following spring may provide a more accurate representation of wild brood outmigrant composition for this system. While this would complicate future cohort analyses, such yearling releases may provide reliable estimates of early marine survival alone (assuming yearlings migrate to sea shortly after release). The combination of CWT fry and smolt releases for each brood would provide estimates of fry-to-smolt and early marine survival, while increasing CWT recoveries and improving exploitation and harvest rate estimates. Of course, rearing fry to the smolt stage would incur an added cost to the program.

10.0 Conclusions

1) While it is not known whether the relatively low CWT recoveries for this stock reflect true absolute survival rates of a northern stream-type chinook stock, changes in adult abundance tended to correlate with changes in hatchery-reared CWTd fry survival. However, there is some evidence that in some years, freshwater flow events occurring during the egg-to-fry stage may have adversely impacted wild fry production, but which would not have been reflected in the fry-to-age 2 survival of hatchery releases.

2) Kitsumkalum chinook escapements have generally not reflected changes in abundance in other Skeena chinook populations (with the possible exception of the Cedar River). However similarity in harvest patterns suggests that exploitation rates on Kitsumkalum chinook are probably representative of the harvest pressures on Zymoetz, Babine and Fulton River stocks. The same is probably not true for early run Cedar River and upper Bulkley River chinook.

3) Stock-recruit analyses indicate that up until 1998, exploitation of this stock was probably too high for long-term stock survival. However, reductions in Canadian harvest in 1998 have reduced exploitation by 50%.

4) Assuming exploitation rates do not increase significantly, then based on a moderate to high FAT survival estimate for the incomplete 1993 and 1994 broods, and the strong return of five year olds in the 1998 escapement, 1999 escapement should surpass that of 1998.

11.0 Recommendations

1) The Kitsumkalum chinook stock should continue to be used as a north coast exploitation indicator. However, exploitation rates and patterns for this summer run stock do not appear to be indicative of those of early run stocks. Consequently, consideration should be given to starting such a program on a north coast spring stock.

2) The relatively low survival rate of CWT fish released to this system reduces the precision of survival, harvest and exploitation rate estimates. Furthermore, with the current fry release program, fry-to-smolt and early marine survival rates cannot be differentiated. The program could therefore be improved by:

- continuing to collect heads from a sample of adipose-clipped fish captured during tagging (14 males and 14 females) for CWT recovery when low escapement is anticipated, and

- increasing the number of eggs collected annually to 250,000. This would allow the release of 200,000 fed-fry the following spring, and an additional 50,000 CWT fish to be held for release as yearlings.

3) Consideration should be given to a fry/smolt monitoring program to augment the adult mark-recapture and CWT fry release programs. Such a program would provide estimates of egg-to-fry mortality and juvenile production. With a continuous temperature and flow monitor now in place, fry abundance estimates would help establish the relationship between egg-to-fry survival, and early rearing conditions.

4) Increased exploitaiton of this stock should be avoided where possible, at least until brood survival rates improve.

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Table 1. Age structure of Kitsumkalum chinook escapement, by sex and return year, from scale and fin aging samples, and CWT recoveries.

Males

	Return Year																														All Years Combined	
	1984 [1]		1985 [2]		1986 [1]		1987 [2]		1988 [2]		1989 [2]		1990 [2]		1991 [2]		1992 [2]		1993 [2]		1994 [2]		1995 [2]		1996 [2]		1997 [3]		1998 [4]			
Total Age	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	1.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.1
3	5	5.9	6	4.5	6	3.7	3	3.2	5	3.3	1	0.8	7	3.8	1	1.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	5.9	12	6.2	37	2.6
4	18	21.2	22	16.4	23	14.2	7	7.5	19	12.5	2	1.5	32	17.6	11	14.5	3	3.0	5	4.9	0	0.0	0	0.0	1	14.3	4	7.8	24	12.3	147	10.3
5	18	21.2	64	47.8	69	42.6	17	18.3	22	14.5	31	23.5	29	15.9	14	18.4	49	48.5	20	19.4	18	13.3	6	42.9	4	57.1	21	41.2	75	38.5	382	26.8
6	44	51.8	42	31.3	64	39.5	66	71.0	100	65.8	95	72.0	110	60.4	36	50.0	48	47.5	78	75.7	111	82.2	7	50.0	0	0.0	20	39.2	84	43.1	823	57.7
7	0	0.0	0	0.0	0	0.0	0	0.0	6	3.9	3	2.3	2	1.1	12	15.8	1	1.0	0	0.0	6	4.4	1	7.1	2	28.6	3	5.9	0	0.0	36	2.5
Sample Size	**85**		**134**		**162**		**93**		**152**		**132**		**182**		**76**		**101**		**103**		**135**		**14**		**7**		**51**		**195**		**1427**	
Weighted Avg Age	**5.19**		**5.06**		**5.18**		**5.57**		**5.55**		**5.73**		**5.34**		**5.64**		**5.47**		**5.71**		**5.91**		**5.64**		**5.43**		**5.31**		**5.18**		**5.47**	
																												Simple Avg Age		**5.46**	

Females

	Return Year																														All Years Combined	
	1984 [1]		1985 [2]		1986 [1]		1987 [2]		1988 [2]		1989 [2]		1990 [2]		1991 [2]		1992 [2]		1993 [2]		1994 [2]		1995 [2]		1996 [2]		1997 [3]		1998 [4]			
Total Age	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.0
3	0	0.0	0	0.0	1	0.4	0	0.0	0	0.0	1	0.5	3	1.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.4	5	0.2
4	1	0.4	4	1.4	0	0.0	0	0.0	1	0.3	0	0.0	26	10.2	1	0.6	0	0.0	0	0.0	5	7.4	0	0.0	1	1.4	0	0.0	2	0.7	39	1.4
5	74	28.8	203	71.5	120	42.4	36	19.8	36	10.6	31	14.6	27	10.5	44	26.0	63	31.0	20	8.1	16	23.5	15	15.6	19	26.8	34	43.6	103	38.1	738	26.9
6	164	63.8	77	27.1	161	56.9	146	80.2	299	87.9	176	83.0	197	77.0	100	59.2	140	69.0	227	91.5	47	69.1	81	84.4	49	69.0	44	56.4	160	59.3	1908	69.5
7	18	7.0	0	0.0	1	0.4	0	0.0	4	1.2	4	1.9	2	0.8	24	14.2	0	0.0	1	0.4	0	0.0	0	0.0	2	2.8	0	0.0	4	1.5	56	2.0
Sample Size	**257**		**284**		**283**		**182**		**340**		**212**		**256**		**169**		**203**		**248**		**68**		**96**		**71**		**78**		**270**		**2747**	
Weighted Avg Age	**5.77**		**5.26**		**5.57**		**5.80**		**5.90**		**5.86**		**5.65**		**5.87**		**5.69**		**5.92**		**5.62**		**5.84**		**5.73**		**5.56**		**5.61**		**5.72**	
																													Simple Avg Age		**5.71**	

Combined

	Return Year																														All Years Combined	
	1984 [1]		1985 [2]		1986 [1]		1987 [2]		1988 [2]		1989 [2]		1990 [2]		1991 [2]		1992 [2]		1993 [2]		1994 [2]		1995 [2]		1996 [2]		1997 [3]		1998 [4]			
Total Age	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	0.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	0.1
3	5	1.5	6	1.4	7	1.6	3	1.1	5	1.0	2	0.6	10	2.3	1	0.4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	2.3	13	2.8	55	1.2
4	19	5.6	26	6.2	23	5.2	7	2.5	20	4.1	2	0.6	58	13.2	12	4.9	3	1.0	5	1.4	5	2.5	0	0.0	2	2.6	4	3.1	26	5.6	212	4.6
5	92	26.9	267	63.9	189	42.5	53	19.3	58	11.8	62	18.0	56	12.8	58	23.7	112	36.8	40	11.4	34	16.7	21	19.1	23	29.5	55	42.6	178	38.3	1298	28.0
6	208	60.8	119	28.5	225	50.6	212	77.1	399	81.1	271	78.8	307	70.1	138	56.3	188	61.8	305	86.9	158	77.8	88	80.0	49	62.8	64	49.6	244	52.5	2975	64.1
7	18	5.3	0	0.0	1	0.2	0	0.0	10	2.0	7	2.0	4	0.9	36	14.7	1	0.3	1	0.3	6	3.0	1	0.9	4	5.1	3	2.3	4	0.9	96	2.1
Sample Size	**342**		**418**		**445**		**275**		**492**		**344**		**438**		**245**		**304**		**351**		**203**		**110**		**78**		**129**		**465**		**4639**	
Weighted Avg Age	**5.63**		**5.19**		**5.43**		**5.72**		**5.79**		**5.81**		**5.52**		**5.80**		**5.62**		**5.86**		**5.81**		**5.82**		**5.71**		**5.47**		**5.43**		**5.61**	
																													Simple Avg Age		**5.64**	

[1] from scales collected during tagging and carcass recovery, as well as CWTs in carcass recovery.
[2] from scales collected during carcass recovery only, as well as CWTs in carcass recovery
[3] from scales collected from sacrificed CWT fish during live tagging, and from scales, fins and CWTs collected during carcass recovery.
[4] same as above, but no fins sampled

Table 2. Size at age in Kitsumkalum chinook escapement by return year and sex.

Males	Return Year																													
	1984		1985		1986		1987		1988		1989		1990		1991		1992		1993		1994		1995		1996		1997		1998		Total	Weighted
Age	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean
2													2	605																		
3	5	334	6	339.7	6	340	3	366.7	5	366.4	1	390	7	397	1	300													12	437.5	34	357.3
4	18	575.6	22	597.7	23	594.3	7	539	19	583.9	2	620	32	613.2	11	658.2	3	583.3	5	589.2					1	620			24	656.0	143	641.7
5	18	765	64	786	69	814.1	17	788.7	22	921.8	31	817.9	29	792.9	14	804.9	49	777.5	20	775.1	18	817.9	6	750	4	782.5	5	834	76	817.2	366	802.4
6	44	891.8	42	922.6	64	940.2	66	933	100	962.7	95	918.4	110	898.7	38	905.5	48	922.4	78	895.8	111	854.2	7	805.7			5	956	84	905.5	808	910.8
7									6	883	3	963	2	885	12	955	1	1040			6	885	1	870	2	980					33	926.0
Total Sample Size and Weighted Mean Length	85	765.2	134	777.9	162	815.2	93	858.7	152	886.7	132	887.3	182	844.1	76	851.0	101	843.2	103	856.5	135	850.7	14	786.4	7	810.0	10	895.0	196	812.1	1384	840.7

Return Year — Simple Mean Length Over All Years: 836.0

Females	Return Year																													Weighted
	1984		1985		1986		1987		1988		1989		1990		1991		1992		1993		1994		1995		1996		1997		1998			
Age	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean
2													1	620																		
3					1	340					1	660	3	600																	5	600.0
4	1	620	4	735					1	810			26	656.2	1	650					5	610			1	760			2	675.0	39	798.5
5	74	786.8	203	805.6	120	823.8	36	829.3	36	801.4	30	816.7	27	834.5	44	799.2	63	823.6	20	823.6	16	755.8	15	798.1	19	800	18	800.5	103	807.3	721	809.4
6	164	865.1	77	878.8	161	898.2	146	966.3	299	867.2	176	873.7	197	861.4	100	857.1	140	869.1	227	869.4	47	886.4	81	843.5	49	847.9	22	846.4	160	859.1	1866	861.1
7	18	881.4			1	990			4	923	4	847.5	2	900	23	907.6			1	1030					2	915			4	890.0	55	899.5
Total Sample Size and Weighted Mean Length	257	842.7	284	824.5	283	865.0	182	955.2	340	878.3	211	865.0	258	855.3	168	847.6	203	855.0	248	866.4	68	835.3	96	836.4	71	835.7	40	826.8	269	838.3	2707	860.7

Return Year — Simple Mean Length Over All Years: 855.2

Combined	Return Year																													Male
	1984		1985		1986		1987		1988		1989		1990		1991		1992		1993		1994		1995		1996		1997		1998			
Age	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n	Mean
2													3	676.7																		
3	5	334.0	6	339.7	7	340.0	3	366.7	5	366.4	2	625.0	10	457.9	1	300.0															39	388.4
4	19	577.9	26	618.6	23	594.3	7	539.0	20	595.2	2	620.0	58	633.4	12	657.5	3	583.3	5	589.2	5	610.0			2	690.0			26	657.5	192	675.3
5	92	782.5	267	800.9	189	820.3	53	816.3	58	847.1	61	817.3	56	813.0	58	800.6	112	803.4	40	799.4	34	788.7	21	784.4	23	797.0	23	807.8	179	811.5	1087	807.0
6	208	870.7	119	894.3	225	910.1	212	969.7	399	906.1	271	889.4	307	874.8	138	870.4	168	882.7	305	878.2	158	863.8	88	840.5	49	847.9	27	868.3	244	875.0	2894	880.0
7	18	881.4			1	990.0			10	899.0	7	897.0	4	892.5	35	923.9	1	1040.0	1	1030.0	6	885.0	1	870.0	4	937.5			4	890.0	88	909.4
Total Sample Size and Weighted Mean Length	342	823.5	418	809.5	445	846.9	275	922.6	492	880.9	343	873.6	438	850.7	244	848.7	304	851.1	351	863.5	203	845.6	110	830.0	78	833.4	50	840.5	453	837.6	4093	853.9

Simple Mean Length Over All Years: 850.5

Table 3. Chinook escapement to the Kitsumkalum River: 1961-1998.

Year	Upper River			Lower River			Total River	% Males	Adult Test Fishery Index to Aug. 15
	Male	Female	Jacks	Male	Female	Jacks			
1961	.	.	.	.	.	.	750		75.69
1962	.	.	.	.	.	.	750		139.303
1963	.	.	.	.	.	.	.		152.38
1964	.	.	.	.	.	.	2000		166.18
1965	.	.	.	.	.	.	1500		129.07
1966	.	.	.	.	.	.	2000		257.91
1967	.	.	.	.	.	.	1500		144.08
1968	.	.	.	.	.	.	1500		212.91
1969	.	.	.	.	.	.	7500		108.31
1970	.	.	.	.	.	.	7500		101.07
1971	.	.	.	.	.	.	7500		91.7
1972	.	.	.	.	.	.	3500		90.04
1973	.	.	.	.	.	.	5000		147.34
1974	.	.	.	.	.	.	5000		130.32
1975	.	.	.	.	.	.	3500		121.05
1976	.	.	.	.	.	.	3500		90.98
1977	.	.	.	.	.	.	7500		96.48
1978	.	.	.	.	.	.	7500		62.13
1979	.	.	.	.	.	.	5000		147.35
1980	.	.	.	.	.	.	4200		102.51
1981	.	.	.	.	.	.	9300		110.47
1982	.	.	.	.	.	.	5500		82.39
1983	.	.	.	.	.	.	10690		125.29
1984	.	.	.	7177	4648	.	11825	61	189
1985	1371	1982	.	2719	2232	.	8304	49	178.48
1986	2546	2643	.	2376	1544	164	9273	54.8 (54.0 [2])	247.39
1987	1751	5391	.	11292	5223	.	23657	55	235.17
1988	2751	4487	.	7731	7299	.	22267	47	230.07
1989	2228	2203	.	5863	7631	.	17925	45	211.08
1990	2633	3992	741	4727	6054	.	18147	44.6 (42.3 [2])	222.59
1991	1439	1479	.	3048	3322	.	9288	48	198.8
1992	2556	4047	.	3598	2236	.	12437	62	182.67
1993	2211	2613	.	4021	5214	.	14059	44	256.98
1994	953	903	.	6560	4213	.	12629	60	175.69
1995	341	567	.	2746	3566	.	7220	43	113.76
1996	.	571	.	6435	5397	.	12403	52	242.99
1997	883	625	.	2356	1478	.	5342	61	191.27
1998	1869	2008	.	3550	2094	1544 [1]	11065	62.9 (56.9 [2])	186.62
							Mean	52.6 (52.0 [2])	

[1] Jack estimate is for total river

[2] Excludes jacks

Table 4. Observed and estimated Kitsumkalum chinook CWT recoveries by fishery.

	Alaska				Canada											
	Commercial		Sport		Northern Commercial		Other Commercial		Tidal Sport		Freshwater Sport		Escapement		Total Recoveries	
Brood Year	Obs	Est	Obs	Est	Obs	Est	Obs	Est	Obs	Est	Obs	Est	Obs	Est	Obs	Est
1979	12	40	2	8	2	8	0	0	0	0	0	0	5	30	21	86
1980	15	46	1	4	20	92	2	2	0	0	1	5	20	96	59	245
1981	13	51	0	0	17	65	0	0	1	5	0	0	44	268	75	389
1982	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1983	8	18	0	0	6	18	0	0	1	6	0	0	11	79	26	121
1984	45	120	9	36	53	174	0	0	6	39	8	48	64	621	185	1038
1985	26	66	3	6	25	81	1	2	6	24	8	38	44	276	113	493
1986	5	15	0	0	6	15	0	0	0	0	1	5	9	50	21	85
1987	54	136	8	6	61	200	2	6	11	40	2	8	62	515	200	911
1988	11	26	2	3	20	62	0	0	3	12	0	0	11	122	47	225
1989	4	9	1	0	13	32	1	2	1	2	2	9	1	36	23	90
1990	10	25	1	5	12	30	0	0	3	7	2	7	8	119	36	193
1991	22	60	16	23	56	122	0	0	8	29	11	45	43	365	156	644
1992	31	79	7	46	25	51	0	0	3	11	3	15	63	385	132	587
1993	8	15	3	12	6	12	0	0	0	0	0	0	33	216	50	255
1994	18	42	2	4	0	0	0	0	0	0	0	0	10	89	30	135

Table 5. Distribution of catch mortality for Kitsumkalum chinook by catch year, all ages combined (includes incidental mortalities). Fishery catch as % of total catch; total catch and escapement as % of catch+escapement.

	Alaska									Canada							
Calendar Year	Wint/Sprg Troll	June In Troll	June Out Troll	July In Troll	July Out Troll	Fall Troll	Net	Tidal Sport	Total	North Troll	North Net	Other Comm	Tidal Sport	Term Sport	Total	Total Catch	Escapement
1981	4.1	0.0	32.5	0.0	42.7	0.0	5.1	2.6	87.1	0.0	13.0	0.0	0.0	0.0	13.0	Unk	Unk
1982	0.9	0.0	16.6	0.0	23.2	0.0	0.3	0.4	41.3	16.5	41.4	0.8	0.0	0.0	58.7	Unk	Unk
1983	0.0	0.0	5.9	0.0	30.6	0.0	10.2	0.0	46.7	10.8	41.6	0.1	0.9	0.0	53.3	Unk	Unk
1984	2.6	0.0	28.4	0.0	24.2	0.0	0.0	1.3	56.6	20.2	23.3	0.0	0.0	0.0	43.4	Unk	Unk
1985	0.1	0.0	10.0	0.0	47.0	0.0	0.0	0.1	57.1	14.6	28.0	0.0	0.3	0.0	42.9	50.5	49.5
1986	0.7	0.4	6.3	0.2	24.1	0.0	0.2	2.1	34.1	33.0	23.6	2.0	1.7	5.5	65.9	41.5	58.5
1987	0.9	1.0	7.9	0.6	27.2	0.0	0.7	1.9	40.3	28.9	17.9	0.1	7.0	5.9	59.7	36.3	63.7
1988	7.3	3.1	0.3	2.8	29.2	0.0	2.3	1.3	46.3	9.4	31.8	0.1	6.0	6.4	53.7	57.8	42.2
1989	3.6	1.3	1.5	3.1	22.8	0.0	2.8	8.6	43.7	12.8	26.8	0.1	8.5	8.2	56.3	43.5	56.5
1990	2.7	2.6	0.1	0.1	29.4	0.0	0.0	2.5	37.3	22.2	17.6	1.0	5.3	16.4	62.7	36.7	63.3
1991	1.7	7.5	3.6	5.5	14.3	0.0	0.2	2.8	35.6	16.3	23.9	1.5	11.3	11.5	64.5	60.8	39.2
1992	22.5	1.8	1.4	0.9	11.9	0.0	0.0	2.7	41.1	18.0	22.5	1.1	14.1	3.2	58.9	40.6	59.4
1993	9.0	2.0	0.1	0.2	13.3	0.0	3.7	4.7	33.0	20.7	37.0	0.0	9.3	0.0	67.0	49.6	50.4
1994	4.9	0.8	0.3	0.3	26.1	0.0	0.0	5.6	37.9	11.2	36.8	0.0	14.0	0.0	62.1	47.8	52.2
1995	0.4	1.6	0.0	3.0	19.5	0.0	0.0	5.2	29.7	12.3	45.9	2.0	2.9	7.2	70.4	61.0	39.0
1996	0.7	1.8	0.0	1.0	17.8	0.0	0.3	11.6	33.3	4.1	41.1	0.0	14.8	6.7	66.8	45.1	55.0
1997	3.6	2.3	1.5	1.0	23.7	0.0	0.0	19.6	51.7	0.0	21.4	0.0	8.1	18.9	48.3	40.2	59.8
1998	14.1	0.0	3.8	2.2	27.6	12.0	0.0	19.3	78.9	0.0	6.4	0.0	7.3	7.3	21.1	20.4	70.6

Note: Wint/Spg = winter/spring, In = Inside, Out = Outside, Other Comm = Central net+ WCVI troll+ Central troll, Term=terminal

Table 6. Escapement of Kitsumkalum chinook by return and brood year based on the age composition of the total escapement.

	Wild Plus Hatchery Escapement																	Hatchery Escapement By Total Age					
	Return Year																						
Brood Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Sum of All Brood Escapements	Age 3	Age 4	Age 5	Age 6	Age 7	Total Wild Brood Escapements (Total Brood Escapements - Hatchery Escapements)
1977 [1,2]	-	326															326	-	-	-	-	-	326
1978 [1,2]	-	6681	0														6681	-	-	-	-	0	6681
1979 [2]	-	2658	2424	15													5297	-	-	-	32	0	5265
1980 [2]	-	1538	4966	4391	0												10895	-	-	76	61	0	10758
1981 [2]	-	422	731	3942	17771	552											23418	-	28	184	272	27	22907
1982 [1,2]		0	183	722	4484	17260	369										23018	-	-	-	-	-	23018
1983			0	203	982	2765	13987	168									18105	0	0	51	28	0	18026
1984				0	421	1345	3338	12627	1390								19121	6	18	399	201	0	18497
1985					0	345	123	2350	5084	61							7963	6	47	186	46	0	7678
1986						0	108	2445	2077	7258	32						11920	0	5	31	21	0	11863
1987							0	429	678	4936	11884	334					18261	10	78	454	73	0	17646
1988								128	59	183	1841	9713	221				12145	0	0	62	68	0	12015
1989									0	0	303	2205	5031	2007			9546	0	0	0	36	0	9510
1990										0	0	376	1969	4119	191		6655	0	12	51	82	0	6510
1991											0	0	0	5274	2457	61	7792	0	0	149	186	0	7457
1992												0	0	1003	2250	5430	8683	0	75	187	130	-	8291
1993 [2]													0	0	254	4243	4497	0	16	200	-	-	4281
1994 [2]														0	191	887	1078	17	73	-	-	-	988
1995 [2]															0	444	444	0	-	-	-	-	444
1996 [2]																0	0	-	-	-	-	-	0
Total Return Year Escapement	-	11825	8305	9273	23657	22270	17923	18145	9288	12437	14057	12629	7221	12403	5343	11065							

[1] No CWT releases.
[2] Incomplete broods

Table 7. Percent distribution of reported catch for north coast chinook stocks based on estimated CWT recoveries.

		Alaska				Canada						
Stock	Catch Year	Troll	Net	Sport	Total Alaskan	Northern Troll	Northern Net	Tidal sport	Freshwater Sport	Other	Total Canadian	Total No. Estimated CWTs
Cedar	1990	34.3	0.0	0.0	34.3	0.0	8.6	0.0	57.1	0.0	65.7	35
	1991	0.0	0.0	0.0	0.0	0.0	7.8	5.9	86.3	0.0	100.0	51
	1992	52.2	0.0	0.0	52.2	7.2	0.0	0.0	40.6	0.0	47.8	69
	1993	20.0	0.0	0.0	20.0	12.0	0.0	32.0	36.0	0.0	80.0	25
	1994	16.7	11.1	0.0	27.8	0.0	0.0	27.8	11.1	33.3	72.2	18
	1995	0.0	0.0	0.0	0.0	0.0	37.5	0.0	62.5	0.0	100.0	8
	1996	15.4	0.0	0.0	15.4	0.0	11.5	53.8	19.2	0.0	84.6	26
	1997	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	3
Kitsumkalum	1990	32.7	0.0	2.4	35.1	21.6	21.2	5.3	15.9	1.0	64.9	208
	1991	28.2	0.0	6.1	34.3	16.0	26.5	10.5	11.0	1.7	65.7	181
	1992	36.2	0.0	2.3	38.5	18.5	24.2	14.6	3.1	1.2	61.5	260
	1993	24.8	1.8	2.8	29.4	22.9	38.5	9.2	0.0	0.0	70.6	109
	1994	24.5	0.0	0.0	24.5	13.2	45.3	17.0	0.0	0.0	75.5	53
	1995	22.5	0.0	4.9	27.5	14.7	48.0	3.9	3.9	2.0	72.5	102
	1996	25.5	0.0	13.9	39.4	0.0	46.2	4.8	9.6	0.0	60.6	208
	1997	29.6	0.0	21.7	51.3	0.0	21.3	8.3	19.2	0.0	48.8	240
	1998	62.3	1.9	16.0	80.2	0.0	0.0	13.2	6.6	0.0	19.8	106
Zymoetz (Copper)	1985	62.5	0.0	0.0	62.5	0.0	0.0	0.0	37.5	0.0	37.5	8
	1987	0.0	0.0	12.5	12.5	0.0	87.5	0.0	0.0	0.0	87.5	32
	1988	12.3	0.0	0.0	12.3	0.0	50.6	7.4	29.6	0.0	87.7	81
	1989	26.1	4.3	0.0	30.4	6.5	15.2	15.2	32.6	0.0	69.6	46
	1990	0.0	0.0	0.0	0.0	33.3	33.3	0.0	33.3	0.0	100.0	15
Bulkley	1990	0.0	0.0	0.0	0.0	28.6	0.0	35.7	35.7	0.0	100.0	14
	1991	0.0	0.0	0.0	0.0	4.9	11.1	8.6	75.3	0.0	100.0	81
	1992	0.0	0.0	0.0	0.0	0.0	9.4	0.0	90.6	0.0	100.0	64
	1993	0.0	0.0	0.0	0.0	0.0	0.0	15.0	65.0	20.0	100.0	20
	1994	0.0	0.0	6.0	6.0	0.0	11.9	3.0	79.1	0.0	94.0	67
	1995	0.0	0.0	0.0	0.0	0.0	62.1	37.9	0.0	0.0	100.0	29
	1996	0.0	0.0	4.2	4.2	0.0	13.4	9.2	73.1	0.0	95.8	119
	1997	0.0	4.0	3.0	7.1	0.0	28.3	0.0	64.6	0.0	92.9	99
	1998	0.0	0.0	0.7	0.7	0.0	6.1	0.0	93.2	0.0	99.3	148
Kispiox	1983	27.3	13.6	0.0	40.9	0.0	59.1	0.0	0.0	0.0	59.1	22
	1984	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	4
	1985	0.0	0.0	0.0	0.0	57.1	0.0	42.9	0.0	0.0	100.0	7
	1986	0.0	0.0	0.0	0.0	50.0	0.0	50.0	0.0	0.0	100.0	8
	1987	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	12
	1988	0.0	14.3	0.0	14.3	0.0	85.7	0.0	0.0	0.0	85.7	14
	1989	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	49
	1990	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	3
	1991	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	3
Babine	1990	55.7	0.0	0.0	55.7	21.8	19.5	0.0	2.9	0.0	44.3	348
	1991	26.1	0.0	0.2	26.3	38.8	31.1	1.8	1.0	1.0	73.7	498
	1992	3.4	0.6	1.4	5.4	39.2	49.3	1.4	1.6	3.0	94.6	497
	1993	8.0	1.1	0.0	9.1	51.0	36.4	1.7	1.1	0.8	90.9	363
	1994	6.1	0.0	0.0	6.1	51.8	28.7	5.5	0.0	7.9	93.9	164
	1995	23.2	1.3	2.6	27.1	36.8	31.6	2.6	1.9	0.0	72.9	155
	1996	29.1	0.0	0.0	29.1	0.0	62.8	6.0	2.1	0.0	70.9	436
	1997	34.4	0.0	3.7	38.1	22.9	24.7	5.8	7.6	0.9	61.9	433
	1998	41.3	0.0	0.0	41.3	26.1	3.3	21.7	0.0	7.6	58.7	92
Fulton	1981	16.5	0.0	0.0	16.5	39.2	44.3	0.0	0.0	0.0	83.5	79
	1982	21.8	7.9	0.0	29.7	16.8	48.5	0.0	0.0	5.0	70.3	101
	1983	50.3	1.1	0.0	51.4	12.7	31.5	1.7	0.0	2.8	48.6	181
	1984	36.4	0.0	0.0	36.4	41.8	21.8	0.0	0.0	0.0	63.6	110
Kincolith	1989	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	100.0	141
	1990	32.7	6.3	4.0	43.0	15.3	40.4	1.3	0.0	0.0	57.0	379
	1991	16.8	2.6	18.4	37.8	7.6	51.6	3.1	0.0	0.0	62.2	543
	1992	32.9	2.4	0.0	35.3	61.8	0.6	2.4	0.0	0.0	64.7	170
	1993	20.2	20.2	2.8	43.1	0.0	56.9	0.0	0.0	0.0	56.9	109
	1994	8.3	4.2	60.4	72.9	0.0	27.1	0.0	0.0	0.0	27.1	48
	1995	11.7	7.8	0.0	19.5	0.0	75.3	0.0	0.0	5.2	80.5	77
	1996	6.1	3.0	0.0	9.1	0.0	86.4	4.5	0.0	0.0	90.9	66
	1997	23.8	14.3	28.6	66.7	23.8	9.5	0.0	0.0	0.0	33.3	42
	1998	41.7	0.0	33.3	75.0	0.0	25.0	0.0	0.0	0.0	25.0	12
Yakoun	1991	50.0	0.0	0.0	50.0	50.0	0.0	0.0	0.0	0.0	50.0	6
	1992	10.0	0.0	0.0	10.0	50.0	3.3	36.7	0.0	0.0	90.0	30
	1993	28.7	0.0	0.0	28.7	66.7	0.0	0.0	0.0	4.7	71.3	171
	1994	37.8	2.4	5.1	45.3	43.2	0.6	10.9	0.0	0.0	54.7	331
	1995	56.3	0.8	0.0	57.1	25.4	0.0	17.5	0.0	0.0	42.9	126
	1996	100.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	34
	1997	0.0	100.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	1
	1998	0.0	12.5	0.0	12.5	0.0	0.0	87.5	0.0	0.0	87.5	8

Table 8. Correlation between Kitsumkalum escapement and escapement of other Skeena stocks, as well as the Skeena adult chinook test fishery index, for years 1984-1998. P-values are uncorrected for multiple comparisons. Stocks ordered by approximate geographical proximity to the Kitsumkalum in either a downstream or upstream direction. r=correlation coefficient; n=sample size; p=p-value.

Downstream: **Years 1961-1983**

	Ecstall	Kloiya	Kasiks	Exchamsiks	Magar	Gitnadoix	Exstew	Lakelse	Erlandsen	Kitsumkalum
r	-0.401	-0.352	-0.236	-0.236	-	**-0.642**	-0.312	0.26	-	-
n	22	22	19	19	0	**17**	11	20	5	-
p	0.064	0.108	0.332	0.071	-	**0.005**	0.351	0.269	-	-

Years 1984-1998

	Ecstall	Kloiya	Kasiks	Exchamsiks	Magar	Gitnadoix	Exstew	Lakelse	Erlandsen	Kitsumkalum
r	0.249	-0.23	-0.249	-0.211	-0.142	-0.217	-0.439	0.415	0.218	-
n	10	13	15	12	14	13	11	14	15	-
p	0.488	0.449	0.379	0.511	0.627	0.477	0.177	0.14	0.436	-

Upstream: **Years 1961-1983**

	Kitsumkalum	Cedar	Clear	Zymoetz (Copper)	Kitwanga	Shegunia	Sweetin	Kispiox	Morice	Nanika	Babine Fence	Bear	Bear +Kispiox +Morice	Test Fishery Index
r	-	**0.425**	-0.085	0.398	0.18	-	0.04	0.023	-0.184	-0.402	-0.4	-0.267	**0.523**	-0.411
n	-	**22**	17	18	17	7	12	22	22	16	22	22	**22**	22
p	-	**0.049**	0.708	0.102	0.49	-	0.901	0.918	0.412	0.123	0.065	0.229	**0.013**	0.057

Years 1984-1998

	Kitsumkalum	Cedar	Clear	Zymoetz (Copper)	Kitwanga	Shegunia	Sweetin	Kispiox	Morice	Nanika	Babine Fence	Bear	Bear +Kispiox +Morice	Test Fishery Index
r	-	**0.73**	0.19	0.197	-0.14	**0.603**	0.05	0.115	-0.274	-0.138	0.133	-0.085	-0.238	0.511
n	-	**15**	15	11	14	**15**	14	15	15	15	15	15	15	15
p	-	**0.002**	0.498	0.562	0.634	**0.017**	0.865	0.682	0.322	0.625	0.637	0.764	0.393	0.052

Figure 1. Map of the Kitsumkalum River study area.

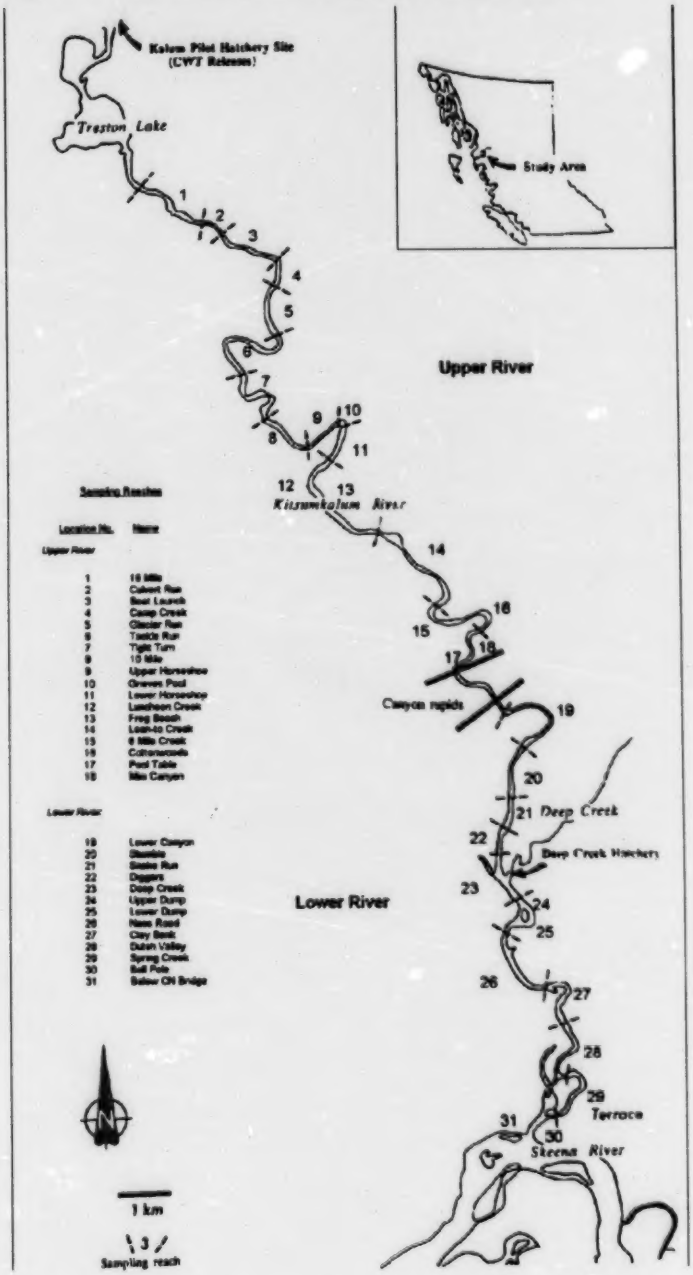


Figure 2. Age composition of Kitsumkalum chinook escapement

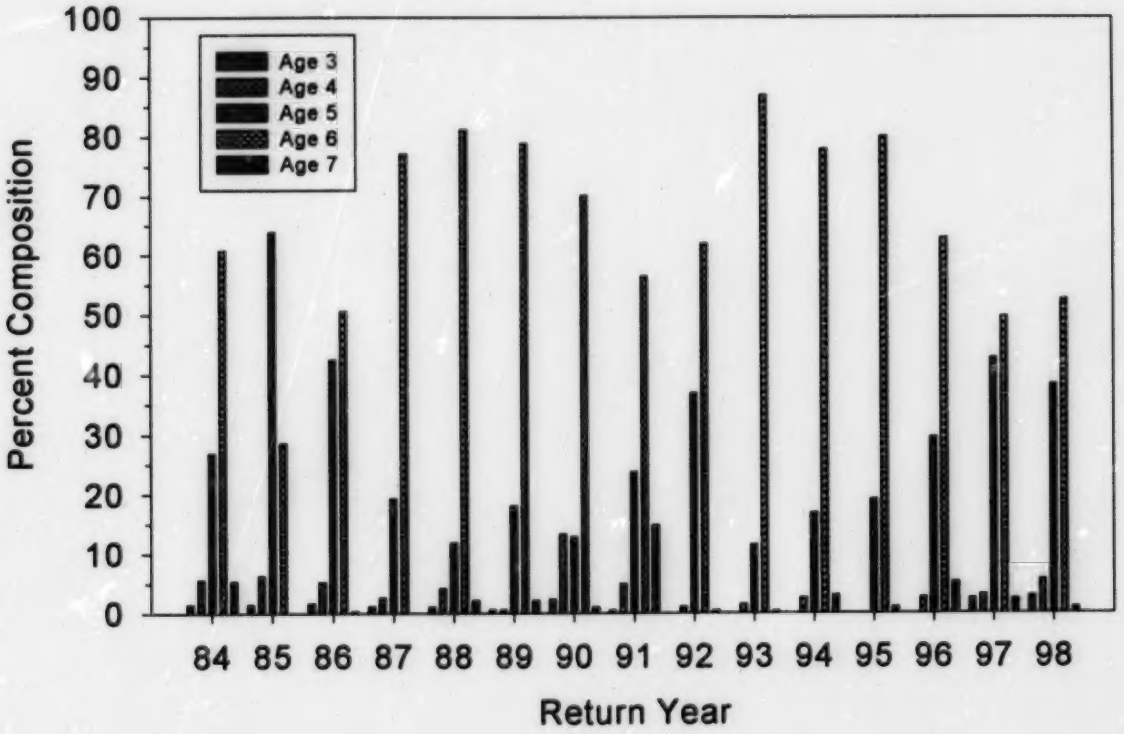


Figure 3. Size composition of Kitsumkalum chinook escapement by return year and sex

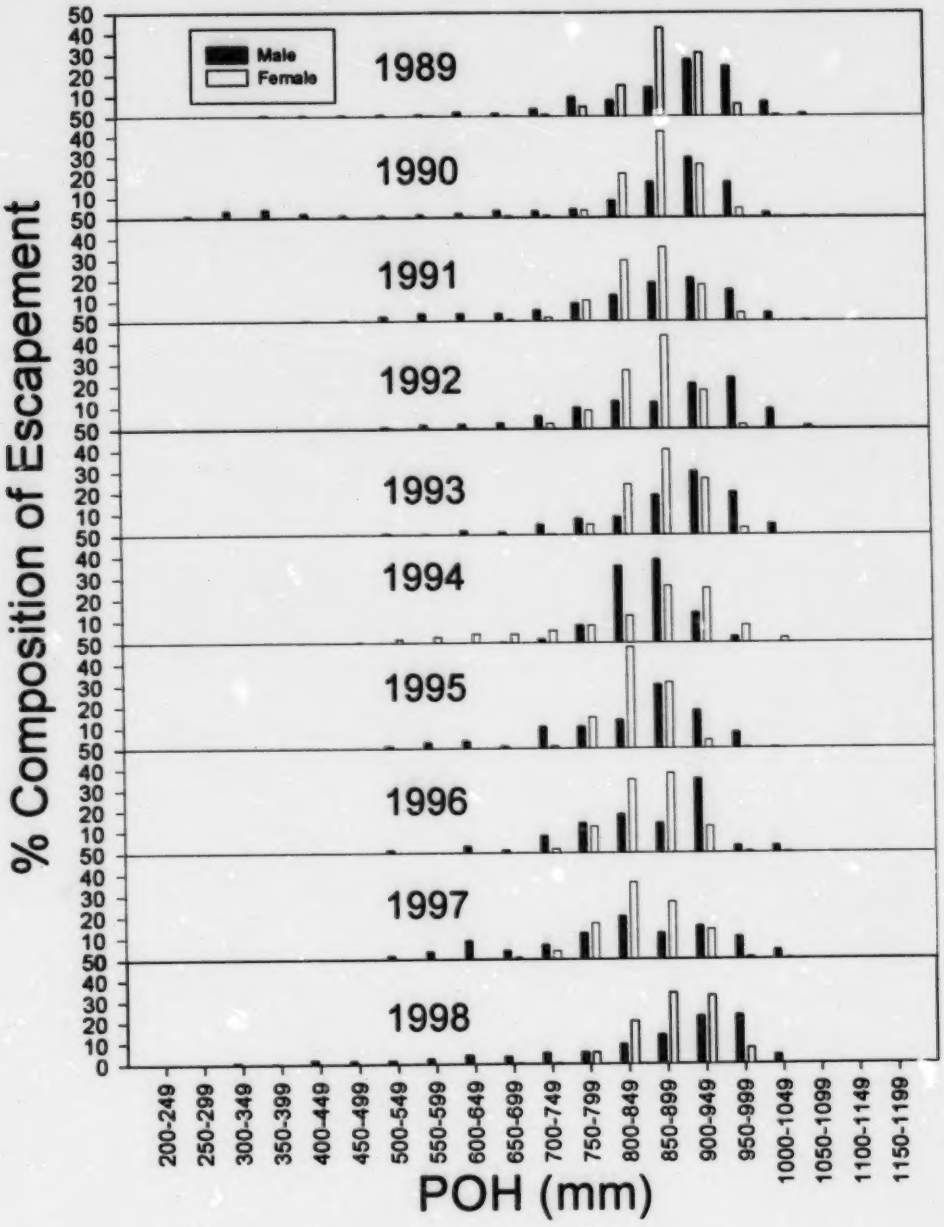


Figure 4. Mean size at age of escapement by return year and sex

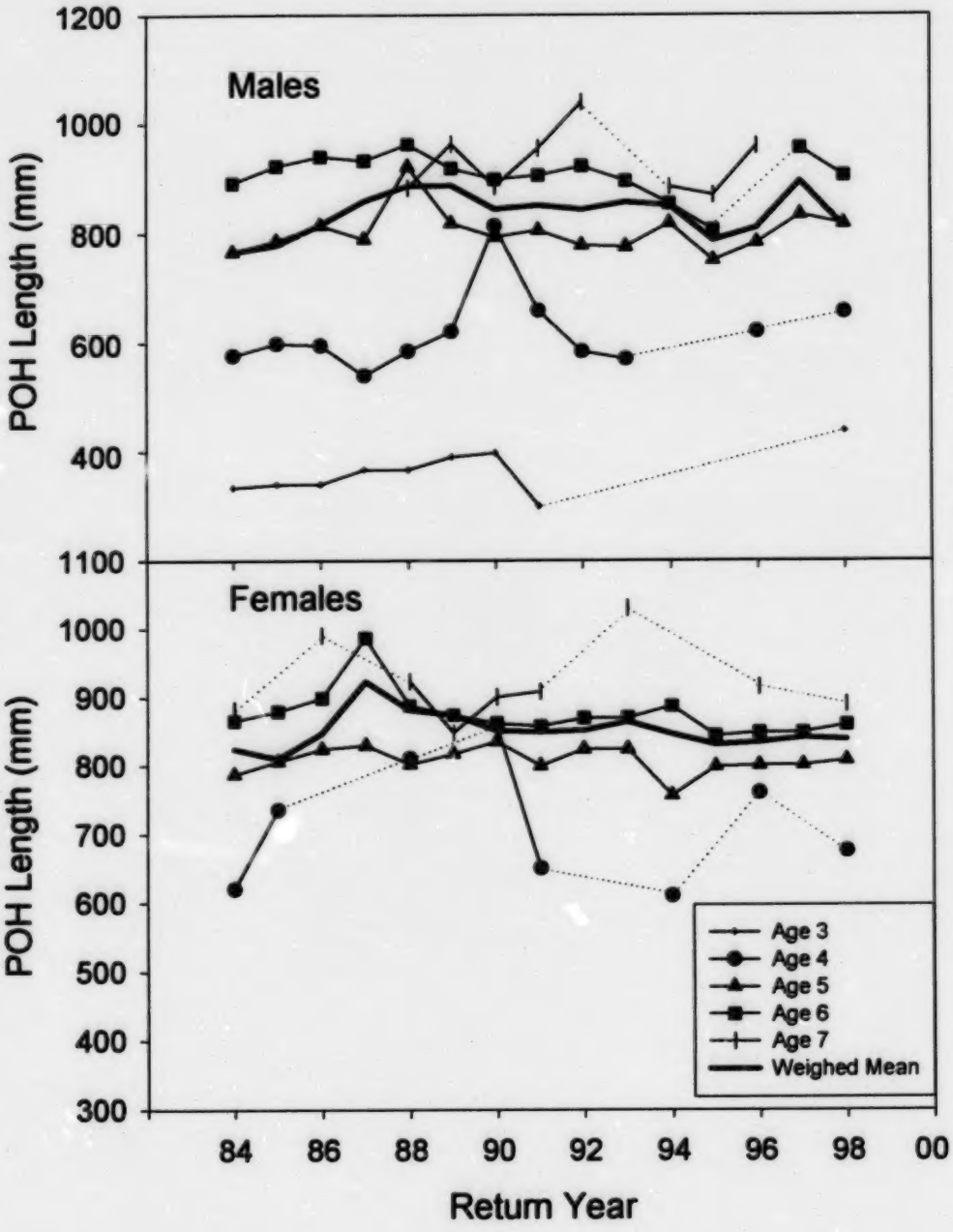


Figure 5. Length-fecundity relationship for Kitsumkalum chinook from 1994 and 1998 brood stock.

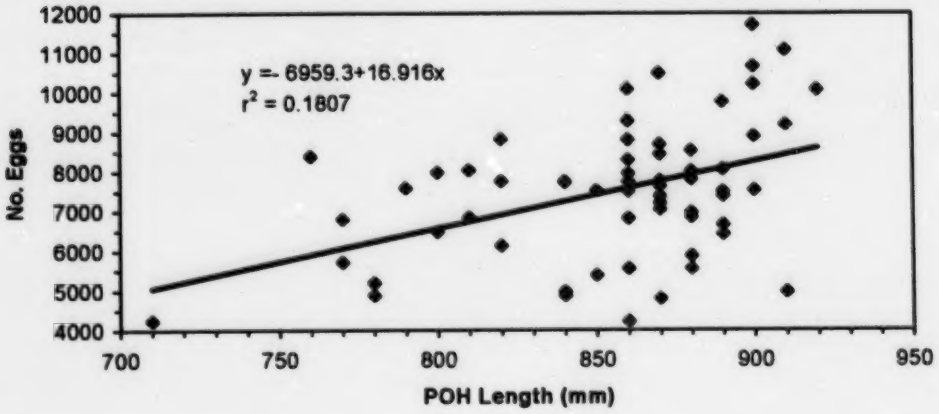


Figure 6. Percentage contribution of hatchery returns to Kitsumkalum chinook escapement. Number of hatchery releases for dominant return year in thousands. * indicates return years affected by the zero release in 1982.

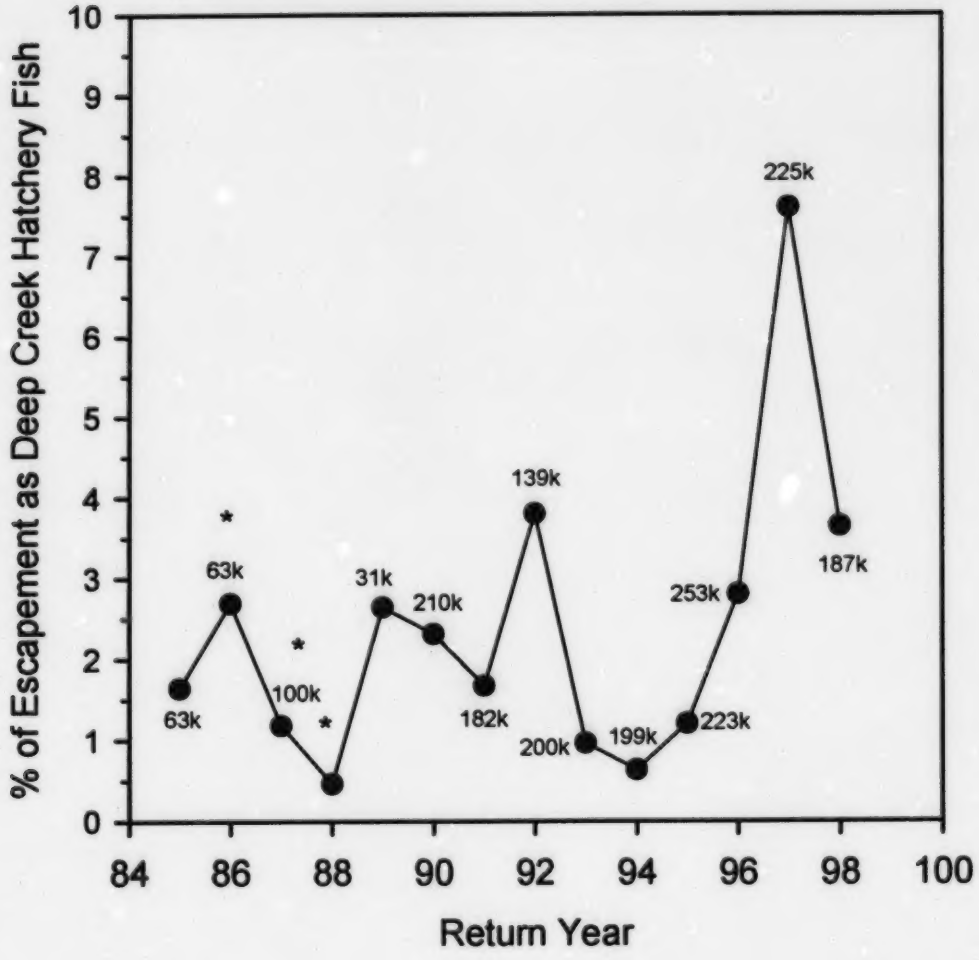
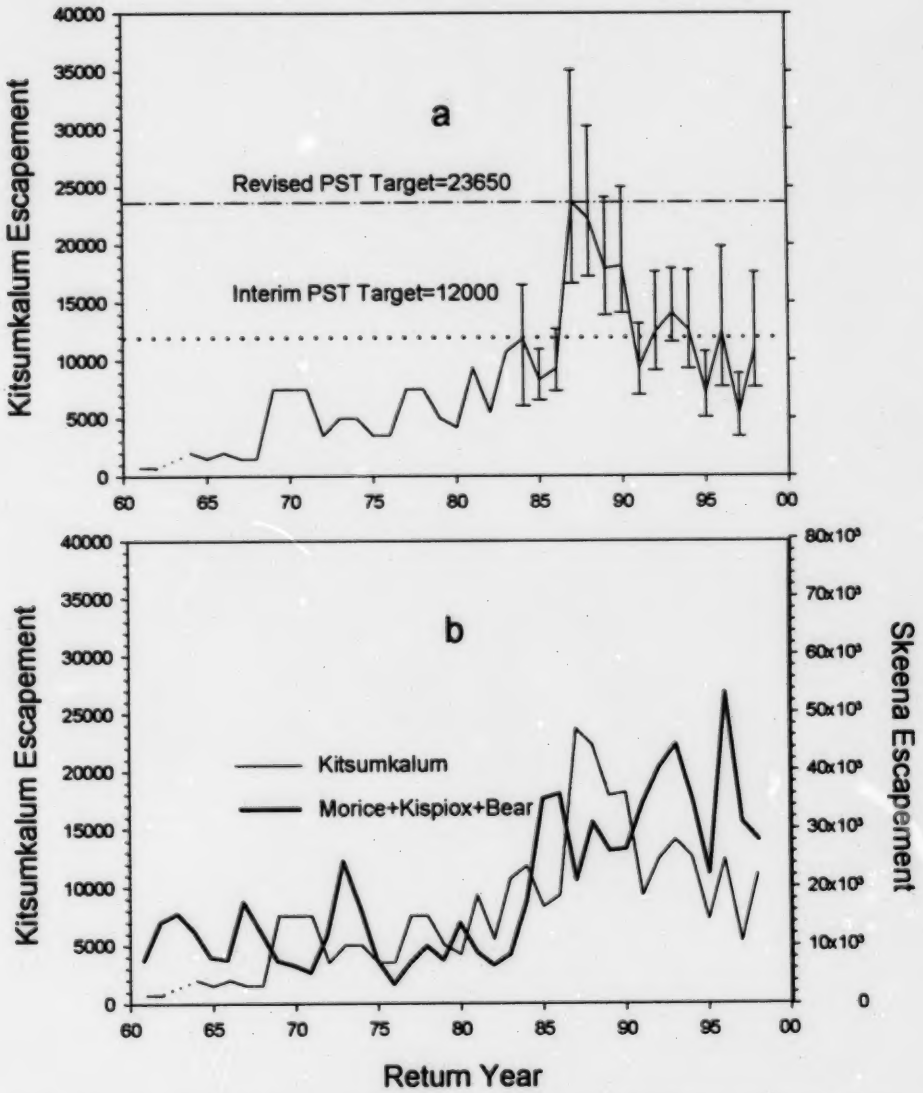


Figure 7. Chinook escapement to the Kitsumkalum River since 1961. a) Kitsumkalum escapement with 95% confidence limits for mark-recapture estimates. b) Comparison of Kitsumkalum escapement to the summed escapement of the other three major Skeena chinook stocks (missing values for any one year were replaced with the mean of the previous and subsequent year's escapement).



Note: escapements to the Kitsumkalum prior to 1984 were derived from visual estimates.

Figure 8. Plot of no. of Kitsumkalum chinook jacks captured during adult tagging in comparison to cumulative Skeena test fishery jack index (up to August 15), and Babine fence jack count

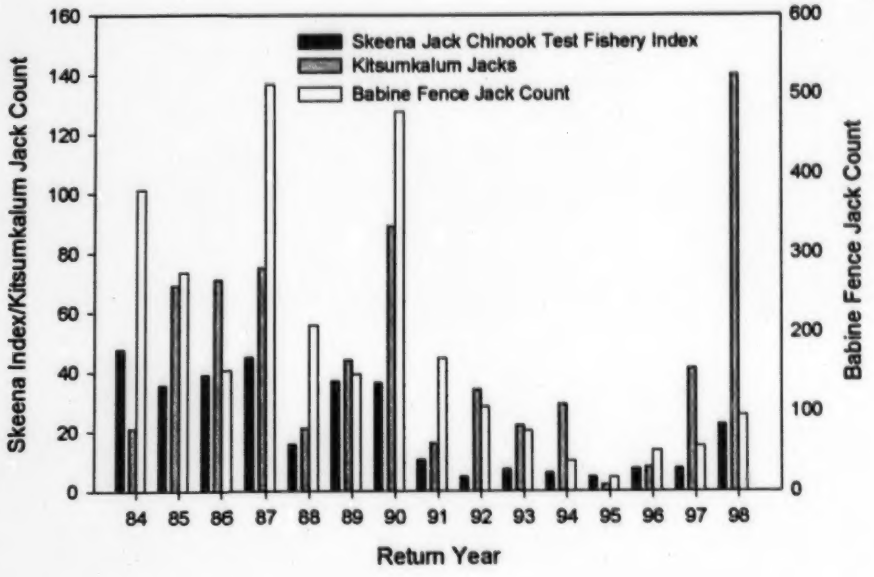
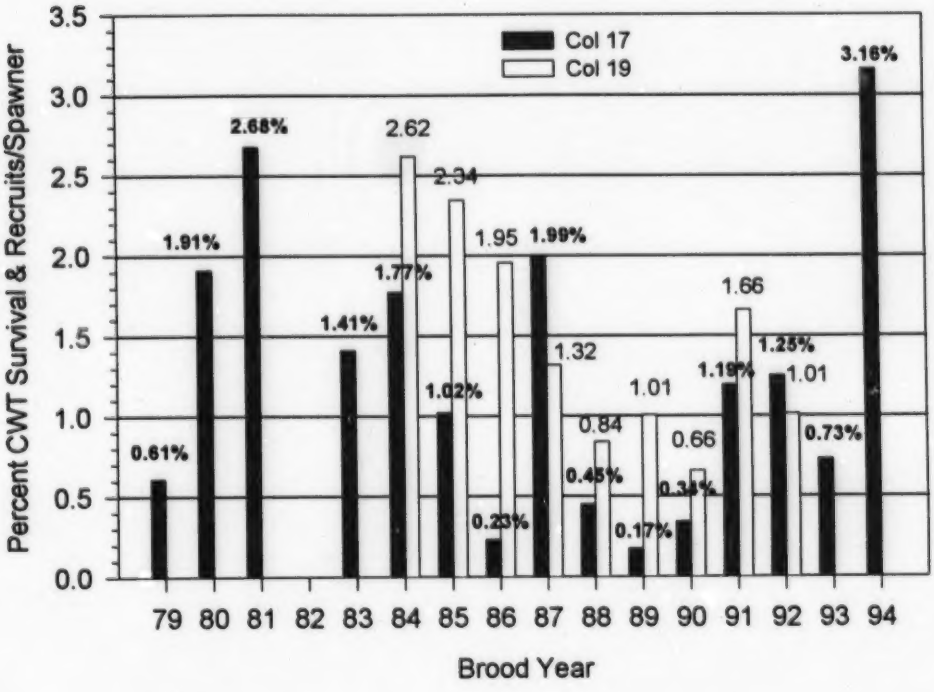


Figure 9. Estimated survival of CWT fish to age 2 and number of adult recruits per spawner (R/S). Note that the survival rate for the 1979 brood release does not include age 5 escapement; there were no 1982 brood CWT releases.



Median Survival (1979-1994): 1.19%
Mean Survival (1979-1994): 1.26%

Median R/S (1984-1992): 1.32
Mean R/S (1984-1992): 1.49

Fig. 10. Total estimated CWT recoveries for Kitsumkalum chinook by statistical week from the 1979-1995 broods.

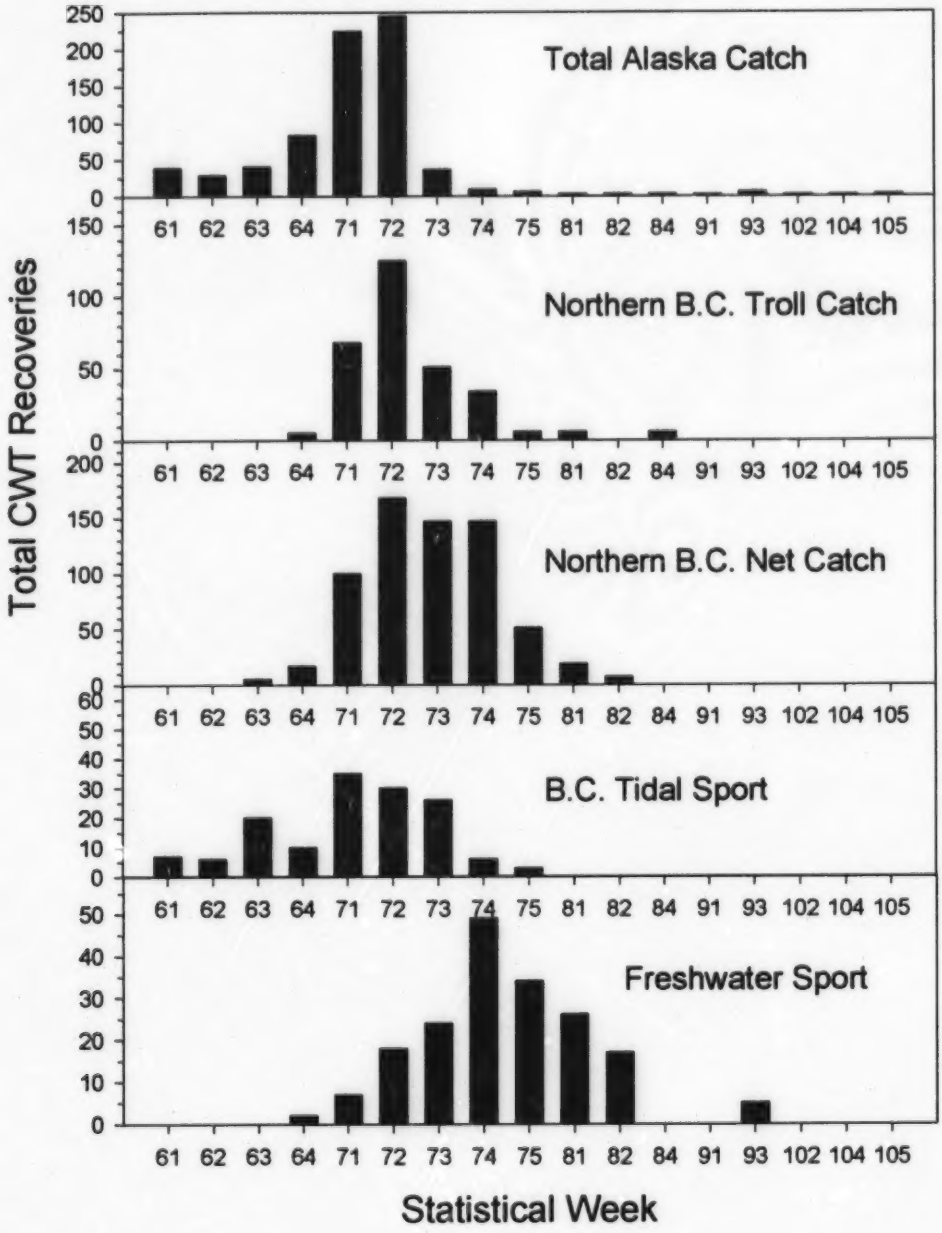

Total CWT Recoveries
Total Alaska Catch
Northern B.C. Troll Catch
Northern B.C. Net Catch
B.C. Tidal Sport
Freshwater Sport
61 62 63 64 71 72 73 74 75 81 82 84 91 93 102 104 105
Statistical Week

Figure 11. Distribution of fishing-related mortality for Kitsumkalum chinook by country.

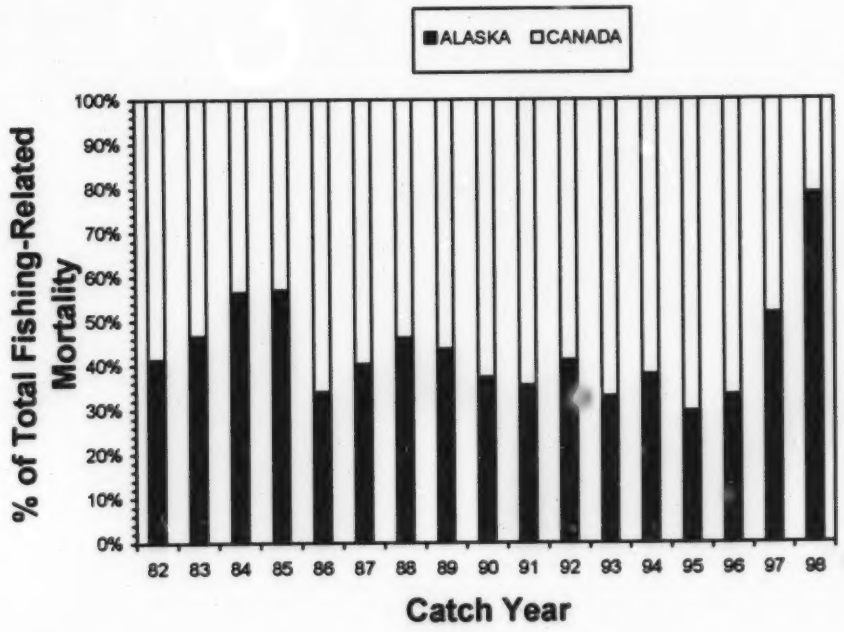


Figure 12. Kitsumkalum chinook exploitation rates by brood year (using adult equivalents).

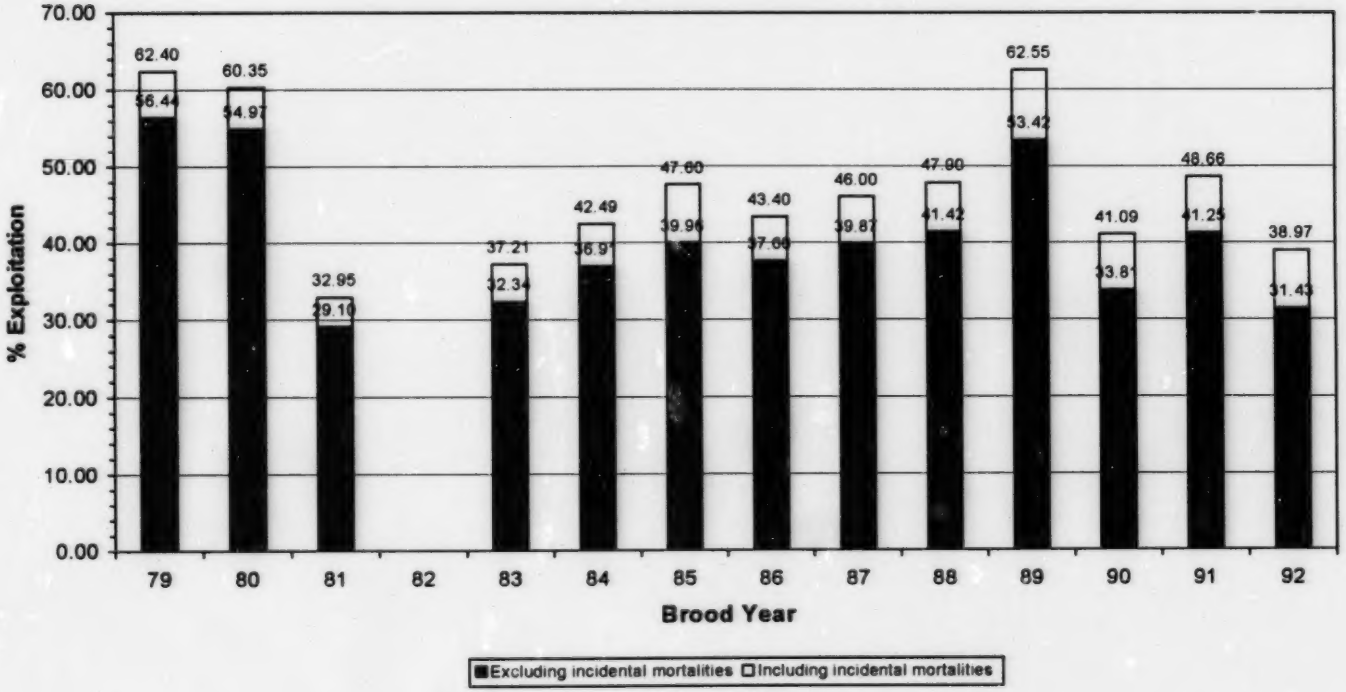
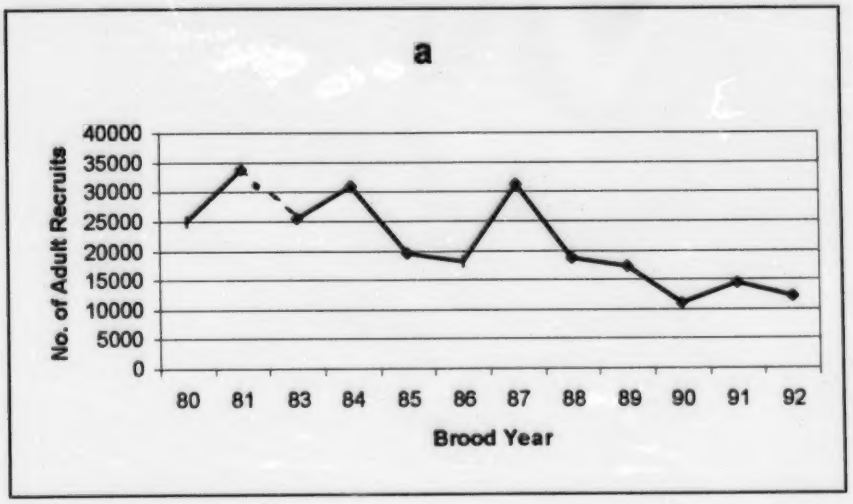


Figure 13. Adult production from the Kitsumkalum summer chinook stock. a) Recruitment by brood year. b) Adult recruits per spawner relationship.



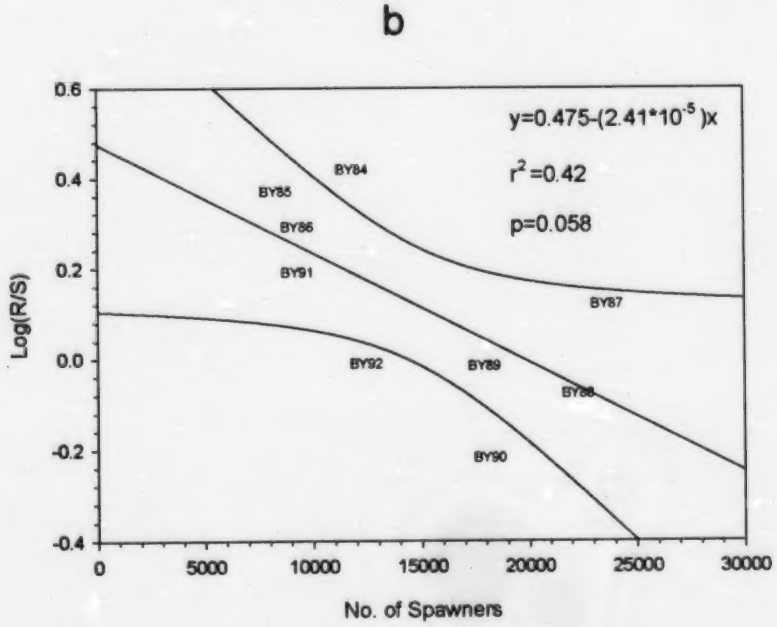


Figure 14. Output from a stock-recruit analysis of Kitsumkalum chinook data using SRSHOW software. A Ricker relationship was assumed, and a maximum likelihood criterion used for curve fitting; a) the best-fit Ricker curve; b) the narrow line represents the posterior distribution of U_{opt} taking into account uncertainty in the estimation of U_{opt} and S_{opt}; c) time trend in residuals for the best-fitting Ricker curve.

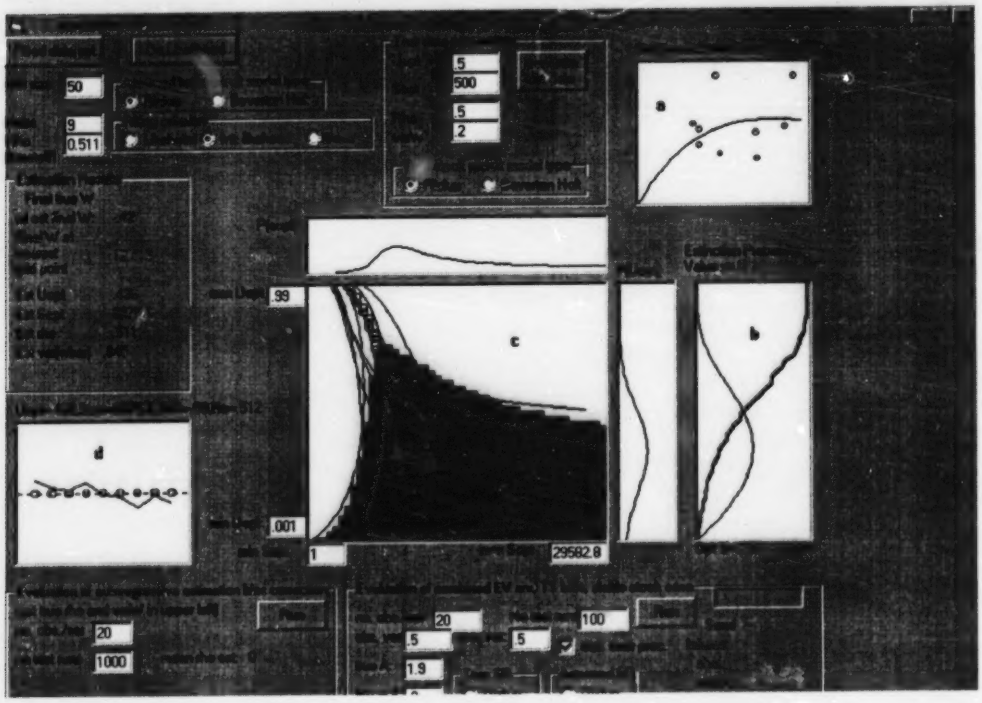
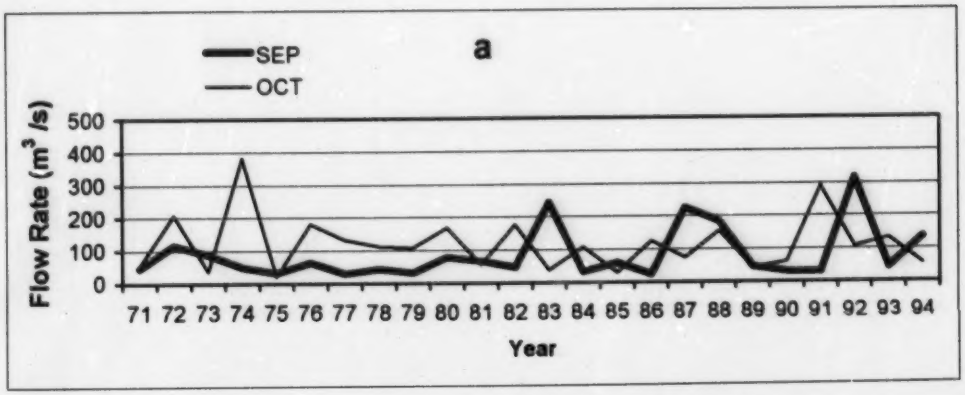
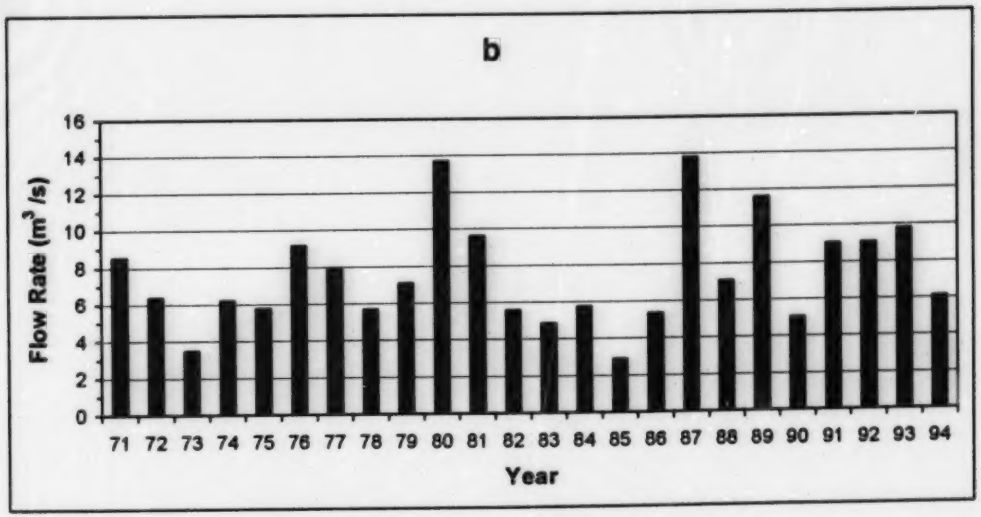


Figure 15. Plots of flow rates for the Zymagotitz River (neighbour to the Kitsumkalum River) indicating a) maximum daily flow for September and October, and b) minimum daily flow for November, for the years 1971-1994. Note the high flows in October/91 and September/92, as well as the low November flow in 1985.





Appendix 1. CWT release information for Kitsumkalum chinook.

Tag Code	Brood Year	Number Tagged	% Tag Loss	Number Released	% CWT Marked	Weight (g)	Release Date
20211	75	1207	7.15	1300	92.8	-	Sept/76
	Brood Total	**1207**		**1300**			
20126	76	25853	0	25853	100	3.02	May-July/77
22055	76	1500	0	1500	100	-	May/78
	Brood Total	**27353**		**27353**			
22052	77	58200	0	58200	100	4.12	June/78
	Brood Total	**58200**		**58200**			
21852	79	48091	7.3	51890	92.7	3	July/80
	Brood Total	**48091**		**51890**			
21951	80	44273	0	63115	70.1	2.1	May 5/81-June 2/81
	Brood Total	**44273**		**63115**			
22312	81	23234	1	30250	76.8	2.1	May 5-6/82
22313	81	29459	1	70400	41.8	2.1	May 5-6/82
	Brood Total	**52693**		**100650**			
22758	83	30716	0	30716	100	5.4	June 6/84
	Brood Total	**30716**		**30716**			
23346	84	25937	0.8	26146	99.2	3	May 28/85
23347	84	26198	0.8	26409	99.2	2.5	May 1/85
23348	84	25978	0.7	26161	99.3	2.5	May 1/85
23349	84	26373	0.4	26466	99.6	2.5	May 6/85
23350	84	25980	0.3	26071	99.7	3	May 28/85
23351	84	26376	0	26376	100	2.5	May 6/85
23352	84	26509	0	26509	100	2.5	May 7/85
23353	84	24512	0	26171	93.7	2.5	May 7/85
	Brood Total	**207863**		**210309**			
23704	85	44183	0.4	44446	99.4	2.5	May 2/86
23705	85	42264	0.4	42500	99.4	2.5	May 5/86
23706	85	43916	0.4	47422	92.6	3.3	June 2/86
23707	85	43892	0.4	47571	92.3	3	June 2-3/86
	Brood Total	**174255**		**181939**			
24410	86	24827	1.6	25230	98.4	3.4	May 5/87
24411	86	25221	0.7	29968	84.2	3.1	May 5/87
24412	86	26784	0	26784	100	2.8	May 5/87
24413	86	26783	0.4	26891	99.6	3	May 5/87
24414	86	26581	0.5	29715	89.5	2.5	May 5/87
	Brood Total	**130196**		**138588**			
24941	87	27021	0.5	27154	99.5	2.9	May 10/88
24942	87	26570	1.7	27030	98.3	3.7	May 10/88
24943	87	25262	0.8	33817	74.7	2.9	May 10/88
24944	87	26423	1.4	26785	98.6	3.3	May 10/88
25060	87	27522	0	42516	64.7	3.4	May 11/88
25061	87	27475	0	42468	64.7	3.1	May 11/88
	Brood Total	**160273**		**199770**			
26039	88	27131	1	29322	92.5	2.5	April 25-27/89
26040	88	27075	0	28992	93.4	2.5	April 25-27/89
26041	88	26543	1	28727	92.4	2.5	April 25-27/89
26042	88	24080	2	26488	90.9	2.5	April 25-27/89
26043	88	26794	0	28711	93.3	2.5	April 25-27/89
26044	88	26849	0	28766	93.3	2.5	April 25-27/89
26045	88	26299	1	28481	92.3	2.5	April 25-27/89
	Brood Total	**184771**		**199487**			
20940	89	29907	1	30209	99	1.3	April 12-May 7/90
20941	89	27486	0	27486	100	1.3	April 12/90
20942	89	26908	0	26908	100	1.3	April 12-May 7/90
20943	89	26583	0	26583	100	1.3	April 12-May 7/90
20944	89	27058	0	27058	100	1.3	April 12-May 7/90
20945	89	27053	0	32446	83.4	1.3	April 12-May 7/90
20946	89	26553	0	31946	83.1	1.3	April 12-May 7/90
26137	89	4554	0	9947	45.8	1.3	April 12-May 7/90
26138	89	4553	0	9946	45.8	1.3	April 12-May 7/90
	Brood Total	**200655**		**222529**			

Appendix 1. (cont'd)

Tag Code	Brood Year	Number Tagged	% Tag Loss	Number Released	% CWT Marked	Weight (g)	Release Date
21133	90	26376	0	31920	82.6	2.3	May 13-24/91
21134	90	26720	0	32265	82.8	2.3	May 13-24/91
21135	90	26736	0	32281	82.8	2.3	May 13-24/91
21136	90	26783	0	32328	82.8	2.3	May 13-24/91
21137	90	26599	0	32143	82.8	2.3	May 13-24/91
21138	90	26722	0	32267	82.8	2.3	May 13-24/91
21139	90	26624	0	32169	82.8	2.3	May 13-24/91
21140	90	21952	0	27496	79.8	2.3	May 13-24/91
	Brood Total	**208512**		**252869**			
21010	91	25634	2	28025	91.5	2.5	May/92
21011	91	26679	0	28585	93.3	2.5	May/92
23116	91	156630	0.3	168390	93	2.5	May/92
	Brood Total	**208943**		**225000**			
181046	92	25635	2	26513	96.7	1.8	June 3/93
181047	92	25811	2	26696	96.7	1.8	June 3/93
181048	92	26357	0.5	26849	98.2	1.8	June 3/93
181049	92	26134	1	26756	97.7	1.8	June 3/93
181050	92	26610	0	26971	98.7	1.8	June 3/93
181051	92	26772	0	27136	98.7	1.8	June 3/93
181052	92	25118	1	25716	97.7	1.8	June 3/93
	Brood Total	**182437**		**186637**			
21104	93	100060	0.3	100311	99.7	2.3	June 4-8/94
181423	93	49902	0.3	50067	99.7	2.3	June 4-8/94
181424	93	50119	0	50119	100	2.3	June 4-8/94
	Brood Total	**200081**		**200497**			
180608	94	10527	0	10711	98.3	2.2	June 13-21/95
180609	94	10700	0	10887	98.3	2.2	June 13-21/95
180640	94	30010	0	30534	98.3	2.2	June 13-21/95
180641	94	29946	0	30469	98.3	2.2	June 13-21/95
180642	94	30867	0	31406	98.3	2.2	June 13-21/95
182155	94	29252	0	29763	98.3	2.2	June 13-21/95
182156	94	30171	0	30698	98.3	2.2	June 13-21/95
182157	94	28943	0	29448	98.3	2.2	June 13-21/95
	Brood Total	**200416**		**203916**			
182339	95	26105	0	26374	99	2.0	June 10-13/96
182340	95	25819	0	26085	99	2.0	June 10-13/96
182341	95	28193	1	28771	98	2.0	June 10-13/96
182342	95	28450	0	28743	99	2.0	June 10-13/96
182343	95	28561	0	28855	99	2.0	June 10-13/96
182344	95	28241	0	28532	99	2.0	June 10-13/96
182345	95	28566	0	28860	99	2.0	June 10-13/96
	Brood Total	**193935**		**196220**			
182749	96	26622	0	27147	98.1	2.4	June 18-20/97
182750	96	28514	0	29076	98.1	2.4	June 18-20/97
182751	96	28609	0	29173	98.1	2.4	June 18-20/97
182752	96	29096	0	29670	98.1	2.4	June 18-20/97
182753	96	29293	0	29871	98.1	2.4	June 18-20/97
182754	96	29002	0	29574	98.1	2.4	June 18-20/97
182755	96	20403	0	20403	100	24.0	April 23-27/98
	Brood Total	**191539**		**194914**			
182806	97	27399	4.5	28690	95.5	2.4	May 15-21/98
182807	97	28803	1	29094	99	2.4	May 15-21/98
182808	97	27132	2.5	27828	97.5	2.4	May 15-21/98
182809	97	29066	0.5	29212	99.5	2.4	May 15-21/98
182810	97	29301	0	29301	100	2.4	May 15-21/98
183307	97	11447	1	11563	99	2.4	May 15-21/98
183308	97	11481	0	11481	100	2.4	May 15-21/98
	Brood Total	**164629**		**167169**			

Appendix 2. Age structure of Kitsumkalum chinook escapement by sex and return year, derived from scales.

	1980						1981						1982					
	Male		Female		Total		Male		Female		Total		Male		Female		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
2_1																		
3_1																		
3_2					2	1.2					1	0.9						
4_1					2	1.2						0.0						
4_2					12	7.2					2	1.8					1	5.0
5_1					6	3.6						0.0						0.0
5_2					108	65.1					59	52.2					4	20.0
5_3						0.0						0.0						0.0
6_1					2	1.2						0.0						0.0
6_2					30	18.1					51	45.1					13	65.0
7_1						0.0												0.0
7_2					4	2.4											2	10.0
7_3																		
Sum					166	100.0					113	100.0					20	100.0
%sub 1						6.0						0.0						0.0
%sub 2						94.0						100.0						100.0
%sub 3						0.0						0.0						0.0

	1984						1985						1986					
	Male		Female		Total		Male		Female		Total		Male		Female		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
2_1		0.0		0.0	0	0.0		0.0		0.0		0.0		0.0		0.0		0.0
3_1		0.0		0.0	0	0.0		0.0		0.0		0.0		0.0		0.0		0.0
3_2	5	5.9		0.0	5	1.5	6	4.5		0.0	6	1.4	6	3.7	1	0.4	7	1.6
4_1		0.0		0.0	0	0.0		0.0		0.0		0.0	2	1.2		0.0	2	0.4
4_2	18	21.2	1	0.4	19	5.6	22	16.4	4	1.4	26	6.2	21	13.0		0.0	21	4.7
5_1	1	1.2	9	3.5	10	2.9		0.0	6	2.1	6	1.4	13	8.0	17	6.6	30	6.7
5_2	17	20.0	65	25.3	82	24.0	64	47.8	197	69.4	261	62.4	56	34.6	103	38.4	159	35.7
5_3		0.0		0.0	0	0.0		0.0		0.0		0.0		0.0		0.0		0.0
6_1		0.0		0.0	0	0.0		0.0		0.0		0.0		0.0		0.0		0.0
6_2	44	51.8	164	63.8	208	60.8	42	31.3	77	27.1	119	28.5	64	39.5	161	56.9	225	50.6
7_1		0.0	16	6.2	16	4.7		0.0		0.0		0.0		0.0		0.0		0.0
7_2		0.0	2	0.8	2	0.6		0.0		0.0		0.0		0.0	1	0.4	1	0.2
7_3		0.0		0.0	0	0.0		0.0		0.0		0.0		0.0		0.0		0.0
Sum	85	100.0	257	100.0	342	100.0	134	100.0	284	100.0	418	100.0	162	100.0	283	100.0	445	100.0
%sub 1		1.18		9.73		7.6		0.0		2.1		1.4		9.3		6.0		7.2
%sub 2		98.8		90.3		92.4		100.0		97.9		98.6		90.7		94.0		92.8
%sub 3		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0

	1987						1988						1989					
	Male		Female		Total		Male		Female		Total		Male		Female		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
2_1		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
3_1	1	1.1		0.0	1	0.4	1	0.7		0.0	1	0.2		0.0		0.0	0	0.0
3_2	2	2.2		0.0	2	0.7	4	2.6		0.0	4	0.8	1	0.8	1	0.5	2	0.6
4_1		0.0		0.0	0	0.0	2	1.3	1	0.3	3	0.6	1	0.8		0.0	1	0.3
4_2	7	7.5		0.0	7	2.5	17	11.2		0.0	17	3.5		0.0		0.0	0	0.0
5_1	1	1.1	8	4.4	9	3.3	2	1.3	5	1.5	7	1.4	5	4.0	6	2.9	11	3.3
5_2	16	17.2	28	15.4	44	16.0	20	13.2	31	9.1	51	10.4	21	16.8	22	10.5	43	12.9
5_3		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
6_1		0.0	1	0.5	1	0.4	1	0.7	1	0.3	2	0.4		0.0		0.0	0	0.0
6_2	66	71.0	145	79.7	211	76.7	99	65.1	298	87.6	397	80.7	94	75.2	176	84.2	270	80.8
7_1		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
7_2		0.0		0.0	0	0.0	6	3.9	4	1.2	10	2.0	3	2.4	4	1.9	7	2.1
7_3		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
Sum	93	100.0	182	100.0	275	100.0	152	100.0	340	100.0	492	100.0	125	100.0	209	100.0	334	100.0
%sub 1		2.1		4.9		4.6		4.3		2.1		3.4		4.8		2.9		3.6
%sub 2		97.8		95.1		96.0		96.1		97.9		97.4		95.2		97.1		96.4
%sub 3		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0

Appendix 2. (cont'd)

	1990						1991						1992					
	Male		Female		Total		Male		Female		Total		Male		Female		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
2_1		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
3_1		0.0	1	0.5	1	0.3		0.0		0.0	0	0.0		0.0		0.0	0	0.0
3_2	6	4.2		0.0	6	1.7	1	1.4		0.0	1	0.4		0.0		0.0	0	0.0
4_1		0.0		0.0	0	0.0	3	4.2		0.0	3	1.3		0.0		0.0	0	0.0
4_2	10	7.0		0.0	10	2.8	6	8.3		0.0	6	2.5	3	3.1		0.0	3	1.1
5_1	3	2.1	7	3.4	10	2.8		0.0	1	0.6	1	0.4	14	14.6	21	11.1	35	12.3
5_2	18	12.6	9	4.3	27	7.7	13	18.1	40	24.4	53	22.5	30	31.3	29	15.3	59	20.7
5_3		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
6_1	4	2.8	8	3.8	12	3.4		0.0	4	2.4	4	1.7		0.0		0.0	0	0.0
6_2	100	69.9	181	87.0	281	80.1	37	51.4	95	57.9	132	55.9	48	50.0	139	73.5	187	65.6
7_1		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
7_2	2	1.4	2	1.0	4	1.1	12	16.7	23	14.0	35	14.8	1	1.0		0.0	1	0.4
7_3		0.0		0.0	0	0.0		0.0	1	0.6	1	0.4		0.0		0.0	0	0.0
Sum	143	100.0	208	100.0	351	100.0	72	100.0	164	100.0	236	100.0	96	100.0	189	100.0	285	100.0
%sub 1		4.9		8.2		7.3		4.2		3.0		3.4		14.6		11.1		12.3
%sub 2		95.1		92.3		93.4		95.8		96.3		96.2		85.4		88.9		87.7
%sub 3		0.0		0.0		0.0		0.0		0.6		0.4		0.0		0.0		0.0

	1993						1994						1995					
	Male		Female		Total		Male		Female		Total		Male		Female		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
2_1		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
3_1		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
3_2		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
4_1	1	1.0		0.0	1	0.3		0.0		0.0	0	0.0		0.0		0.0	0	0.0
4_2	4	3.9		0.0	4	1.2		0.0	5	7.4	5	2.5		0.0		0.0	0	0.0
5_1	3	2.9	4	1.6	7	2.0		0.0	1	1.5	1	0.5		0.0	3	3.1	3	2.8
5_2	17	16.7	14	5.7	31	8.9	18	13.5	15	22.1	33	16.4	5	38.5	12	12.5	17	15.6
5_3		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
6_1		0.0	4	1.6	4	1.2		0.0		0.0	0	0.0		0.0		0.0	0	0.0
6_2	77	75.5	222	90.6	299	86.2	109	82.0	47	69.1	156	77.6	7	53.8	81	84.4	88	80.7
7_1		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
7_2		0.0	1	0.4	1	0.3	6	4.5		0.0	6	3.0	1	7.7		0.0	1	0.9
7_3		0.0		0.0	0	0.0		0.0		0.0	0	0.0		0.0		0.0	0	0.0
Sum	102	100.0	245	100.0	347	100.0	133	100.0	68	100.0	201	100.0	13	100.0	96	100.0	109	100.0
%sub 1		3.9		3.3		3.5		0.0		1.5		0.5		0.0		3.1		2.8
%sub 2		96.1		96.7		96.5		100.0		98.5		99.5		100.0		96.9		97.2
%sub 3		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0

	1996						1997 [1]						1998					
	Male		Female		Total		Male		Female		Total		Male		Female		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
2_1		0.0		0.0	0	0.0		0.0		0.0	0	0.0	0	0.0	0	0.0	0	0.0
3_1		0.0		0.0	0	0.0	3	6.4		0.0	3	2.7	0	0.0	0	0.0	0	0.0
3_2		0.0		0.0	0	0.0		0.0		0.0	0	0.0	12	6.2	1	0.4	13	2.8
4_1		0.0		0.0	0	0.0		0.0		0.0	0	0.0	5	2.6	2	0.7	7	1.5
4_2		0.0	1	1.6	1	1.5	4	8.5		0.0	4	3.6	19	9.7	0	0.0	19	4.1
5_1		0.0	2	3.1	2	2.9		0.0	1	1.6	1	0.9	7	3.6	3	1.1	10	2.2
5_2	2	50.0	14	21.9	16	23.5	19	40.4	24	38.1	43	39.1	68	34.9	100	37.0	168	36.1
5_3		0.0		0.0	0	0.0		0.0		0.0	0	0.0	0	0.0	0	0.0	0	0.0
6_1		0.0		0.0	0	0.0		0.0		0.0	0	0.0	0	0.0	0	0.0	0	0.0
6_2		0.0	45	70.3	45	66.2	19	40.4	38	60.3	57	51.8	84	43.1	160	59.3	244	52.5
7_1		0.0		0.0	0	0.0		0.0		0.0	0	0.0	0	0.0	0	0.0	0	0.0
7_2	2	50.0	2	3.1	4	5.9	2	4.3		0.0	2	1.8	0	0.0	3	1.1	3	0.6
7_3		0.0		0.0	0	0.0		0.0		0.0	0	0.0	0	0.0	1	0.4	1	0.2
Sum	4	100.0	64	100.0	68	100.0	47	100.0	63	100.0	110	100.0	195	100.0	270	100.0	465	100.0
%sub 1		0.0		3.1		2.9		3.0		1.6		3.9		6.2		1.9		3.7
%sub 2		100.0		96.9		97.1		93.6		98.4		96.4		93.8		97.8		96.1
%sub 3		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.4		0.2

[1] Includes fin samples

Appendix 3. Brood adult production by age class. All parameters, except escapement, were obtained from output from the exploitation rate analysis.

AGE 3 RE-CONSTRUCTION OF ADULT PRODUCTION:

Brood Year	Escapement	Terminal Harvest Rate	Mature Return [1]	Maturity Rate	Ocean Population After Pre-terminal Fisheries	Ocean Exploitation Rate	Ocean Population Before Fishing [3]	Fishing Mortality [4]	AEQ Factor	Ocean Adults [5]	Total Adult Production [6]
1979	100 [9]	0	100	*0.0070*	14286	0.0244	14642	356.6712	0.6480	231	331
1980	194 [9]	0	194	*0.0070*	27714	0.0392	28845	1130.6154	0.6822	771	965
1981	422	0	422	*0.0070*	60266	0.0305	62185	1899.1532	0.6744	1281	1703
1983	203	0	203	*0.0070*	29000	0.0257	29766	766.3535	0.6912	530	733
1984	415	0.4732	788	*0.0070*	112539	0.0269	115656	3116.3906	0.6964	2176	2964
1985	339	0.0073	341	0.0078	43781	0.0382	45522	1741.0859	0.7044	1226	1568
1986	106	0	106	0.0085	12706	0.0669	13616	910.2411	0.7020	639	747
1987	419	0.0009	419	*0.0070*	59911	0.0411	62481	2569.7535	0.7129	1832	2251
1988	59	0	59	0.0081	7284	0.0510	7676	391.8160	0.6786	266	325
1989	169 [9]	0	169	*0.0070*	24143	0.0589	25655	1512.1593	0.6539	989	1158
1990	116 [9]	0	116	*0.0070*	16571	0.0506	17455	883.8865	0.6760	598	714
1991	141 [9]	0	141	*0.0070*	20143	0.0137	20423	279.9300	0.6793	190	331
1992	148 [9]	0	148	*0.0070*	21143	0.0275	21741	598.1251	0.5489	328	476

AGE 4 RE-CONSTRUCTION OF ADULT PRODUCTION:

Brood Year	Escapement	Terminal Harvest Rate	Mature Return [1]	Maturity Rate	Ocean Population After Pre-terminal Fisheries	Ocean Exploitation Rate	Ocean Population Before Fishing [3]	Fishing Mortality [4]	AEQ Factor	Ocean Adults [5]	Total Adult Production [6]
1979	334 [9]	0	334	*0.0556*	6007	0.0836	6555	548	0.8100	444	778
1980	1536	0	1536	*0.0556*	27662	0.1818	33810	6148	0.8527	5242	6780
1981	703	0	703	*0.0267*	26330	0.0819	28679	2350	0.8430	1981	2684
1983	982	0	982	0.0556	17662	0.0184	17993	331	0.8639	286	1268
1984	1327	0.02626	1363	*0.0219*	62229	0.0545	65818	3589	0.8700	3123	4485
1985	76	0.0002	76	0.0897	847	0.0985	940	93	0.8774	81	157
1986	2440	0.0001	2440	0.0571	42736	0.0858	46746	4010	0.8775	3518	5959
1987	600	0	600	0.0586	10239	0.0966	11359	1120	0.8882	995	1595
1988	183	0	183	0.0556	3291	0.0993	3654	363	0.8483	308	491
1989	303	0	303	*0.0556*	5450	0.1293	6259	810	0.8174	662	965
1990	364	0.0001	364	*0.0420*	8668	0.0608	9229	561	0.8450	474	838
1991	464 [9]	0	464	0.0556	8345	0.0644	8919	574	0.8491	487	951
1992	928	0.0001	928	*0.0926*	10023	0.0914	11031	1008	0.7841	791	1719

AGE 5 RE-CONSTRUCTION OF ADULT PRODUCTION:

Brood Year	Escapement	Terminal Harvest Rate	Mature Return [1]	Maturity Rate	Ocean Population After Pre-terminal Fisheries	Ocean Exploitation Rate	Ocean Population Before Fishing [3]	Fishing Mortality [4]	AEQ Factor	Ocean Adults [5]	Total Adult Production [6]
1979	2858	0.0000	2858	*0.490*	5831	0.3273	8669	2838	0.9000	2554	5412
1980	4690	0.2838	6828	0.475	14374	0.1933	17819	3444	0.9475	3264	10091
1981	3756	0.1101	4223	0.318	13292	0.0999	14767	1475	0.9318	1374	5597
1983	2714	0.1905	3353	0.599	5594	0.1612	6669	1075	0.9599	1032	4385
1984	2939	0.2211	3773	0.634	5951	0.1864	7314	1364	0.9634	1314	5087
1985	2164	0.1738	2619	0.615	4258	0.1780	5180	922	0.9615	886	3508
1986	2046	0.3860	3332	0.668	4988	0.1456	5837	850	0.9667	821	4154
1987	4482	0.1373	5195	0.792	6560	0.2628	8896	2336	0.9792	2290	7485
1988	1779	0.2362	2335	0.425	5493	0.1800	6699	1206	0.9424	1136	3472
1989	2205	0.2117	2797	0.082	34238	0.0575	36327	2089	0.9082	1897	4694
1990	1918	0.1520	2262	0.314	7215	0.1466	8456	1241	0.9315	1156	3418
1991	5125	0.3030	7353	0.434	16938	0.0844	18500	1562	0.9434	1473	8626
1992	2063	0.1332	2380	0.526	4526	0.0962	5009	482	0.9526	459	2839

Appendix 3. (cont'd)

AGE 6+7 RE-CONSTRUCTION OF ADULT PRODUCTION:

Brood Year	Escapement	Terminal Harvest Rate	Mature Return [1]	Maturity Rate	Ocean Population After Pre-terminal Fisheries	Ocean Exploitation Rate	Ocean Population Before Fishing [3]	Fishing Mortality [4]	AEQ Factor	Ocean Adults [5]	Total Adult Production [6]
1979	2407	0.1176	2728	1	2728	0.2507	3641	913	1	913	3641
1980	4330	0.1869	5325	1	5325	0.2481	7083	1758	1	1758	7083
1981	18024	0.0422	18818	1	18818	0.2123	23891	5073	1	5073	23891
1983	14127	0.0968	15641	1	15641	0.1817	19115	3474	1	3474	19115
1984	13816	0.1065	15463	1	15463	0.1607	18423	2960	1	2960	18423
1985	5099	0.3945	8421	1	8421	0.4067	14242	5821	1	5821	14242
1986	7269	0.0001	7270	1	7270	0.0008	7276	6	1	6	7276
1987	12145	0.2169	15509	1	15509	0.2172	19812	4303	1	4303	19812
1988	9866	0.1351	11407	1	11407	0.2053	14354	2947	1	2947	14354
1989	7002	0.2256	9044	1	9044	0.1378	10490	1446	1	1446	10490
1990	4228	0.2011	5292	1	5292	0.1223	6030	738	1	738	6030
1991	2332	0.288	3275	1	3275	0.2389	4303	1028	1	1028	4303
1992	5300	0.0986	5880	1	5880	0.1755	7131	1251	1	1251	7131

TOTAL PRODUCTION BY BROOD YEAR (SUM OF PRODUCTION AT AGE)

Brood Year	Age 3	Age 4	Age 5	Age 6	Total Brood Production [8]
1979	331	778	5412	3641	10161
1980	965	6780	10091	7083	24920
1981	1703	2684	5597	23891	33875
1983	733	1268	4385	19115	25500
1984	2964	4485	5087	18423	30959
1985	1568	157	3506	14242	19473
1986	747	5959	4154	7276	18135
1987	2251	1595	7485	19812	31144
1988	325	491	3472	14354	18642
1989	1158	965	4694	10490	17307
1990	714	838	3418	6030	11000
1991	331	951	8826	4303	14412
1992	476	1719	2839	7131	12165

1. =Escapement/(1-Terminal harvest rate)
2. Where rates could not be calculated, the mean rate for the other broods was used (bold and italicized)
3. =Mature Return/Maturity Rate
4. =Ocean Population After Pre-terminal Fisheries/(1-Ocean Exploitation Rate)
5. =(Ocean Population Before Fishing)-(Ocean Population After Pre-terminal Fisheries)
6. =Fishing Mortality x AEQ
7. =Mature Return + Ocean Adults
8. Since there were no mark-recapture escapement estimates in 1982 and 1983, direct estimates of age 3 and 4 escapements from the 1979 brood, and age 3 escapement for the 1980 brood, could not be calculated. Therefore, escapement was estimated as a percentage of total escapement, based on the mean percent escapement of the age class in question for the 1981-1988 broods (see Table 6). The zero estimates for age 3 escapement for the 1989-1992 broods, and age 4 escapement for the 1991 brood (see Table 6), were not considered valid, but rather the result of low numbers of ageing samples; therefore for the purpose of calculating production estimates, they were replaced with escapement estimates calculated in the same manner as previously described.
9. =Sum of production for all age classe